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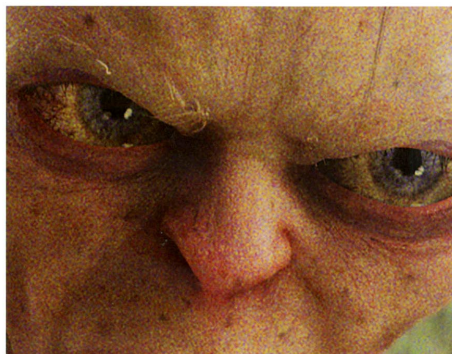
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Working at the Speed of Thought

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ARTICLE BY JODY DUNCAN

When *Spy Kids* was released in spring 2001, it proved to be that rarest of movie experiences — a surprise.

It was a surprise that the man behind the family-friendly action-adventure was *Robert Rodriguez*, an independent, low-budget filmmaker responsible for the gritty and violent *El Mariachi* and its sequel, *Desperado*, as well as *From Dusk Till Dawn* and *The Faculty*, both horrific thrillers with comedic undertones. It was a surprise that, without a star-filled cast or an overblown marketing blitz by its distributor, Dimension Films, it did excellent business, bringing in \$113 million domestically and \$168 million worldwide. It was a surprise that a light-hearted, fantasy film aimed toward a young audience earned kudos from every major film critic.

Most surprising was that *Spy Kids*, featuring a slate of 500 effects shots, was made on a tight schedule, with a budget of only \$35 million. The tale of young Juni (Daryl Sabara) and Carmen Cortez (Alexa Vega), who learn that their seemingly conventional parents are actually international spies and take up the spy mantle themselves when their parents disappear, *Spy Kids* did not look like a \$35 million movie. It featured a lush production design, exotic locations, fantasy-realm vehicles and gadgetry, dynamic action sequences that took place in the skies, on water, underwater and on land, and a host of outlandish characters — some created practically, many computer animated.

Earlier this year, Rodriguez repeated the amazing feat — and in fact, surpassed it — with the release of *Spy Kids 2: The Island of Lost Dreams*. The sequel was made on a similar schedule and with only a slightly higher budget, despite its slate of more than 1,000 effects shots, a number that aligned it with some of the biggest effects extravaganzas of all time. The effects count was mandated by a storyline that had Juni and Carmen — now part of the official ‘spy kids’ division of the OSS intelligence agency — investigating a mysterious island populated by mutant beasts as they search for a powerful cloaking device.

What made both movies-on-a-shoestring possible was Rodriguez’s guerrilla filmmaking style, developed in his teens as he made amateur films and epitomized by the one-man-show that was *El Mariachi*, for which Rodriguez served as writer, producer, director, cameraman, sound mixer and editor. The \$7,000 budget for that project — which the young director earned by subjecting his body to medical research — had left Rodriguez no choice but to do it all: he could not afford a crew. But the principles and methods he relied upon, out of necessity, on *El Mariachi*, he continued to apply out of preference on subsequent larger-scaled, bigger-budgeted shows, gaining him the reputation as a film-industry maverick who eschewed standard movie production practices.

“Coming from a guerrilla-type background,” Rodriguez noted, “the Hollywood system of making movies never made any sense to me. It seemed like a step backward, not a step forward, because it was so difficult. If you have to run an obstacle course just to get the paintbrush to the canvas, your painting is going to suffer. And that is what happens so often in films: ‘That’s it? We spent all this

money and had all this talent, and this is the result?’ It’s because the process is so convoluted, so strenuous, so wrong. Talk to any director, and he will tell you that one of the things he dislikes most about making a movie is the process. You should want to make a movie — not have to wait and build up your stamina for four years before you can bear to do it again because the process has just beaten the shit out of you. Making a movie should be fun!”

More than one ‘Hollywood insider’ director, weary of the exhausting grind of the typical filmmaking process, and more than one studio executive, weary of bloated production budgets, has had to look at the inexpensive yet gleefully outrageous *Spy Kids* movies and wonder: “How does Robert Rodriguez make a \$100 million effects movie for \$35 million — and have fun doing it?”

1. Work outside the Hollywood system.

Spy Kids and *Spy Kids 2*, like all of Rodriguez’s films, were made outside the Hollywood infrastructure — which suits a director inclined to question Hollywood convention just fine. “George Lucas told me, ‘Because you live outside of Hollywood, you are going to come up with things that they won’t think of,’” Rodriguez commented. “It’s true, because Hollywood is so set in its ways. It’s like when you go off to school in another city, and then you come back to your hometown and find your old high school buddies still doing the same things, cruising the same streets — that’s what Hollywood is like. They’re cruising the same two streets. You try to tell them new ways of doing things, and it doesn’t make any sense to them at all.”

The movies were also made almost entirely without studio interference — an enviable situation made possible by budgets so modest the projects were considered extremely low-risk. “I came up with a budget that was so low,” Rodriguez laughed, “even the studio said: ‘Are you sure that’s all you want? Are you sure you can make it for that?’ I arbitrarily made up a budget, allotting a certain amount for effects, and simply decided to do it for that amount — and then creatively figured out how. It was worth it to me because it gave me complete freedom to bring my own ideas of moviemaking to *Spy Kids* and *Spy Kids 2* — everything I had figured out when I was doing things like *El Mariachi*. I still wanted to make a big movie, but I wanted to do it in the backyard way.”

That entailed making the movies literally in his own backyard, shooting as many locations as possible near his base in Austin, Texas, and completing much of the preproduction and postproduction work — editing, composing music, mixing sound, creating animatics — in a well-equipped film studio attached to his self-designed, stone castle-like home. From home, Rodriguez even kept tabs on effects work being done in Quebec, Canada — the location of Hybride, the principal visual effects supplier for both *Spy Kids* movies — and that being done by various vendors in California, through a video conferencing system called Quicktime Synchro, developed by Hybride. “Quicktime Synchro allowed me to supervise all the effects houses from home because I



Spy Kids sprang from the mind of writer/director Robert Rodriguez, an independent filmmaker who turned his attention from grittier cinematic fare to make the lighthearted family adventure. The story concerns two children – Junia and Carmen Cortez (Daryl Sabara and Alexa Vega) – who become embroiled in their parents’ secret lives as international spies working for the OSS intelligence agency. Brimming with visual effects, yet made on a modest budget of only \$35 million, *Spy Kids* met with unanticipated critical acclaim and box office

could see daily updates on shots,” Rodriguez explained. “It was like having a meeting every day, which made it very easy to keep track of everything and to steer people in the right direction.”

success, and promptly spawned a sequel, *Spy Kids 2: The Island of Lost Dreams*. Robert Rodriguez on the set with Antonio Banderas, who portrayed spy kids dad Gregorio Cortez in both films. Through the application of guerrilla-style production tactics, Rodriguez imbued the low-budget *Spy Kids* with a big-budget look and more than 500 visual effects shots. Production was based in Austin, Texas, where Rodriguez maintains a small movie studio attached to his home. From there, the director was able to supervise shots-in-progress at a number of effects houses, employing a real-time video conferencing system developed by Hybride, the show’s main effects provider.



Under visual effects supervisor Daniel Leduc, Hybride created whimsical images and characters – such as ‘Flooglies’ and ‘Thumb-thumbs’ – for a children’s television show hosted by the seemingly beneficent, but inwardly villainous Fegan Floop (Alan Cumming). For a flamboyant production number on the show, Hybride combined greenscreen elements of Cumming and Flooglie performers – in suits and makeups created by KNBEFX Group – with CG characters and environments.



For the Thumb-thumbs – clumsy, ‘all-thumbs’ robots that serve as Floop’s bumbling henchmen – artists at KNB, under supervisor Greg Nicotero, built suits that were worn by actors on set, then replaced in completed shots with Hybride’s computer animated characters.

“We could open up a Quicktime on our screen in California,” said animation supervisor Domenic DiGiorgio of Computer Café, one of the effects vendors on *Spy Kids 2*, “and Robert could open up the same Quicktime in Texas; and, in real time, we could interactively scroll back and forth and watch the animation and talk about it. Robert could also draw right on top of the animations in real time, and we could see that on our screen. It was so much better than trying to verbally describe intricate details, which is very difficult. It allowed us to get a lot closer to what he wanted, and to get there much more quickly.”

2. Plan well.

Through Troublemaker Digital Studios — an offshoot of Rodriguez’s Troublemaker Studios consisting only of the director himself and digital artists Chris Olivia, Alex Toader and Rodney Brunet — Rodriguez produced animatics for every major effects sequence in *Spy Kids*, finding them to be a better communications tool than the storyboards he had drawn for previous projects. “I’d edit those storyboards together, and put sound effects and music to them,” Rodriguez observed, “but I found that people still responded better when they saw an animatic. They could suddenly tell what was going on — even though it was exactly the same as the storyboard, only moving.”

A boat chase in the first *Spy Kids* epitomized the well-planned sequence. “I knew we’d be out on a lake to shoot that,” noted Rodriguez, “and it’s always hard to shoot on water. Usually what happens in a big Hollywood movie is that they will shoot water stuff second unit, and they will be out there a long time; but then they edit the sequence together and most of what they shot is thrown away. Because I’m the editor, I edit my movies in my head first; so it was possible to shoot a big sequence like the boat chase in two days. I’d already done an animatic for it and I’d already edited that animatic, so all we had to do was get the shots we needed. We knew exactly what had to be built, what we had to shoot on the water, and what was going to be CG. We got the shots quickly; and since the sequence was already edited, no shot was unused. You can never over-shoot because the pacing has all been worked out in the animatic.”



Lou Zutavern and Jim Towler, of Big Z Miniatures, built a castle for establishing shots of Floop’s headquarters. The model was photographed via motion control at Image G and composited into aerial locationplates by Hybride.

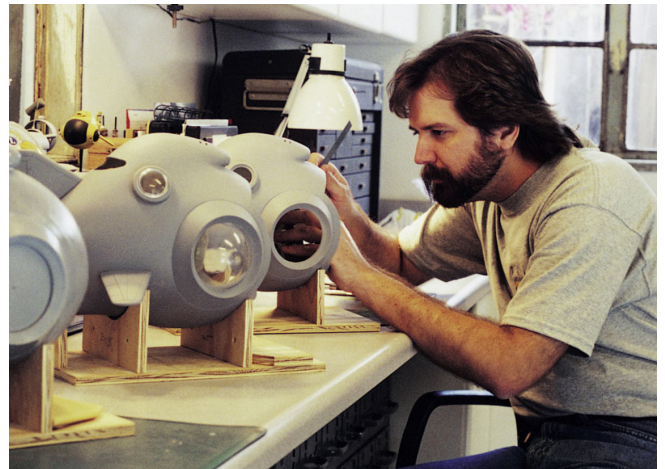
Throughout production of *Spy Kids*, new ideas that occurred to Rodriguez on the day of shooting also benefited from preplanning. “What’s good about being well-prepared,” Rodriguez said, “is that if you come up with something extra because you’re inspired by the set or the location, you know right away if the new idea will fit. And if you don’t have any new ideas, you still have the safety net of a very well thought-out plan. I think you come up with your best ideas when you are writing — when you are really into it and you have your head in the story and you’re not distracted. Anything beyond those ideas is just gravy. And even the new ideas are better if you know exactly where you are going.”

Though he provided animatics for a couple of key action sequences and thoroughly planned every shot in *Spy Kids 2*, Rodriguez produced considerably fewer animatics for the sequel, realizing that the 3D-animated sequences often told his crew more than they needed to know. “After a while, I’d show people animatics and see their eyes glaze over; and I realized that they didn’t need to see what was going to happen — all they needed were their marching orders for any given shot. So we stopped doing animatics, except for sequences that were very greenscreen-heavy.” One such sequence was a climactic battle between the giant Spider-Ape and the Slizzard — mutant beasts inadvertently created by the scientist Romero (Steve Buscemi). Hybride computer animated the characters, while *Spy Kids* riding atop the beasts were shot against greenscreen, on rigs to simulate the creatures’ backs. Animatics clarified precisely what elements were needed, which sped the greenscreen shoot along. “We had scheduled three days of greenscreen for that — and we got it in a day and a half. We just lined up the shots and did one right after another. The animatics — and being well prepared — helped us to do that.”

3. Be your own department heads.



Early in *Spy Kids*, after their parents are reported missing, Juni and Carmen are conveyed by underwater pod to an OSS island safehouse. The Hybride composite featured live-action greenscreen elements of Daryl Sabara and Alexa Vega nestled inside a computer generated pod.



Other shots in the sequence featured miniature pods built by Big Z Miniatures. Throughout the production, models were created in as small a scale as possible to keep costs down. Lou Zutavern details pod models in his shop.

On *Spy Kids*, Rodriguez was credited as co-producer — along with his wife, Elizabeth Avellán — as well as writer, director, editor and visual effects supervisor. He even wrote some of the film's music. Rodriguez wore more hats for *Spy Kids 2*, taking on all of the above roles, plus production designer and director of photography. But his propensity to do it all was not out of ego-fulfillment or control-freakishness — it was simply a matter of efficiency. A typical Hollywood production is woefully inefficient, due in part to its division of departments and the standard structure of 'first unit,' 'second unit' and 'postproduction unit.' "What you end up with is something that feels like three different movies," Rodriguez explained. "The director is shooting one movie with the actors; an action crew is off shooting stunts that you may or may not use; and another separate crew is shooting the effects. I've never liked to split things up like that; because then, instead of an organic whole, it feels like a patched-together *Frankenstein* monster at the end — which it is. People are concentrating on their own area and they aren't thinking about the story, overall. As the writer/director, you're the only one thinking about the overall story; and if you're not there, you don't know where the focus is being put."

By acting as his own department heads, Rodriguez not only unified the moviemaking process, he streamlined it, doing away with the 'cover your butt' syndrome so prevalent in the standard Hollywood production structure, in which crews build more than is necessary, shoot more than is necessary, do more than is necessary — just in case. "Everybody doubles everything because nobody wants to look silly on the set day," commented Rodriguez. "No matter how many times I might ask a production designer for a two-wall set, I get there and there are four walls. That's because they're afraid I'll change my mind and say: 'Where are the other two walls? I want to do a turnaround!' So I get there and they've built this huge set; and suddenly I feel like I have to shoot it because they've put all this work and money into it. It's not what I originally pictured, but I shoot it to take advantage of it — and usually that is the first stuff that gets cut out of the movie, because it wasn't ever supposed to be there in the first place. If I am my own production designer and I know I only need two walls, I only build two walls."

The same philosophy accounted for Rodriguez's decision to serve as visual effects supervisor on *Spy Kids* and *Spy Kids 2*. It was a big leap considering that, just a few years prior to those productions, Rodriguez had known little about digital effects and had demonstrated a strong preference for practical, in-camera effects such as those provided by KNB EFX Group for *From Dusk Till Dawn* and *The Faculty*. "It has been interesting since then to watch Robert grow as a filmmaker," remarked KNB co-founder Greg Nicotero, "particularly in regard to effects. He's a big fan of John Carpenter and George Romero and those guys; so he was much more interested in physical props and puppets and makeup stuff on *From Dusk Till Dawn*, and most of the gags on that movie were those types of



Imprisoned in Floop's castle – where the errant children's showhost is transforming OSS agents into mutant Flooglies – Gregorio and spy-kid mom Ingrid (Carla Gugino) attempt an escape. As they run down a corridor, jigsaw-puzzle-shaped pieces of flooring appear to drop away, creating a breach too wide to be leapt. Hybride digitally manipulated a live-action plate, replacing areas of practical set flooring with a CG model of falling puzzle pieces and a seemingly bottomless chasm.

effects. The few minor visual effects shots we did have, he didn't seem to like dealing with. He was so accustomed to shooting fast — and everyone knows that when you shoot visual effects, everything screeches to a halt. So even as far back as *From Dusk Till Dawn*, he was beginning to think, 'If I'm going to have visual effects in my movies, I need to learn how to incorporate them into my guerrilla style of filmmaking.' He had an insatiable desire to learn and understand everything he could about digital effects."

"In those early movies," added Rodriguez, "I opted to do more stuff on camera because I could control, at least somewhat, whether or not that was working. But even as I was doing that, I was learning as much as I could about visual effects, and especially digital effects, because I knew I would have to use that technology in future projects. I had already been writing *Spy Kids* at that time, and I knew that movie would expand the palette beyond what we could do physically."

By the time Rodriguez commenced shooting on *Spy Kids*, he had learned enough to take on the mantle of visual effects supervisor, yet another step toward making the splintered production process a more unified one. "On my earlier movies, there were many times I'd see how a visual effects supervisor was going about a shot," Rodriguez recalled, "and I'd think, 'There's got to be an easier way and a better way to do that' — but it would involve changing my shot, which a visual effects supervisor would never ask me to do. But I could ask that of myself to make an effect work. It just seemed more organic a process. The more I as the director/editor/cameraman knew about effects, the more it would become part of the whole process instead of something separate. And that has really helped." Acting as visual effects supervisor not only made the effects a more integral part of the whole process, it also sped up that process by allowing for more direct communication. "As visual effects supervisor, I didn't even have to tell anybody what I was doing. I could just say: 'Put this desk in front of this greenscreen and put a big light behind it — and don't even ask me why. It will make sense later when we get the other half in post.' Because I knew what the shot was going to be, and I didn't have to explain it to anybody else, it made the whole



Donning a jetpack and taking flight, Carmen attempts to flee from Floop's Thumb-thumbs. KNB EFX built prop jetpacks for the sequence, two of which were radio-controlled hero versions. Hybride composited greenscreen shots of Alexa Vega on wires with aerial plates captured on location by Robert Rodriguez. Unable to afford motion control, Rodriguez shot the plates as smoothly as he could — hanging his camera out the side of a helicopter — and approximated the same camera moves on the greenscreen stage when photographing his young performer. Camera shake was added in the final composite.



As the jetpack chase escalates, Carmen and her pursuers smash through a rooftop billboard. Lou Zutavern adds finishing touches to a miniature set constructed by Big Z Miniatures for the shot. A revised version of the model was required when Robert Rodriguez shot a new building in downtown Santiago during an impromptu aerial shoot. The final billboard model featured an advertisement for Floop's television show, the artwork for which was supplied by the production art department.

thing go very fast. I knew exactly what the intent of every effects shot was and how it fit into the story; so there was no fat, and I saved a lot of time and money.”

“One of the most interesting things about working for Robert,” noted Domenic DiGiorgio, who oversaw 40 computer animation shots for the Romero’s Zoo and Zoo Too sequences in *Spy Kids 2*, “is that he would sometimes tell us how he wanted something, and it wouldn’t make any sense to us. But once it was cut into the movie, it made perfect sense. Robert obviously understood very well how the whole picture was going to fit together and how each shot fit into that whole. He made all his calls for specific shots based on what he envisioned for the movie, overall.”

A shot in *Spy Kids 2* illustrates the point. Rodriguez envisioned a very wide shot showing spy-kid father Gregorio Cortez (Antonio Banderas) at the controls of an enormous submarine, his wife Ingrid (Carla Gugino) sitting at a matching chair station on the other side. “The shot was meant to show that the father was very much in control,” said Rodriguez, “the master of this big ship. But then the grandparents show up, and they all huddle around his chair and he isn’t in control at all anymore. He looks like he’s on a road trip to hell in a Suburban — even though the ship is huge. The visual joke only pays off because of the previous shot, where the audience saw how big this sub is.” As the effects supervisor, production designer and cameraman, Rodriguez determined that all that was needed on set was a single chair area. He would shoot Banderas in that chair area first; then shoot Gugino in the chair, flip the image and composite them together to make it look as if there were two chairs, one on each side of the sub interior. In the final composite, it would appear that the characters exchanged looks and dialogue, all within the same shot. The vast expanse of the remaining set was then painted in digitally by Hybride. “It was a very old-school idea that allowed me to make the visual statement I wanted to make, without spending a lot of time and money. There were over 1,000 effects shots in *Spy Kids 2*, but every one of them was focused on the story and made a particular point. There was never an effect just for an effect’s sake. By doing these kinds of money-saving tricks from shot to shot, scene to scene, the overall savings was in the tens of millions.”

4. When it comes to effects companies, consider the little guys.

Rodriguez assigned the bulk of effects for *Spy Kids* and *Spy Kids 2* to Hybride, the small Canadian company that had first worked with him on *The Faculty*. Under supervisor Daniel Leduc, Hybride produced 400 of the first film’s 500 effects shots with a team of 20 compositors and a like number of 3D animators and technical directors — a total team of 40, which completed its slate of shots in only four months. Though the number of crew members increased somewhat for *Spy Kids 2*, efficiency and ingenuity led the way on both films due to budgets that were considerably below the average \$50,000 per computer animation shot. “In these films,” said Leduc, “we didn’t have that kind of money, and we didn’t have very much time; so we had to get around that in a number of ways. The Canadian exchange rate helped, of course; and it helped that we are a smaller company with less overhead, so we could charge less.” Beyond those cost-saving factors was Rodriguez’s flexibility in how he envisioned his shots: if his initial idea was too costly and too time-consuming, he would alter it in some way to make it workable. “That open point of view from the director, his willingness to change the way a shot was done, was very important.”

“Robert’s not the kind of guy to throw money at a problem,” agreed Domenic DiGiorgio, “he throws ideas at a problem. If something isn’t exactly how he wants it to be, he can bend a little, or he’ll find another solution. He’ll say: ‘Okay, this isn’t exactly right; but I can make up for it over here, or maybe I can change one little thing here that will make it all work.’ He’s all about ingenuity, which is how he achieves very good results on a very reasonable budget.”

Visual effects supervisor David Lingenfelter of Cinesite, which contributed 62 shots to *Spy Kids 2*, appreciated that flexible directorial approach, as well. “If the framing of a shot wasn’t suitable for the effect and was making it more complicated,”

Lingenfelter commented, “Robert was up for our changing the framing, which is very unusual. Most directors are like, ‘Don’t touch my framing!’ But he was willing to do whatever it took to make something work. There were shots that we blew up almost 50 percent to reframe them, and he never questioned it.”

The same open-mindedness was applied to *Spy Kids*’ practical effects, provided by Los Angeles-based KNB and Lou Zutavern of Big Z Miniatures. Both shops were well-suited to Rodriguez’s lean-and-mean filmmaking style. Working only with partner Jim Towler, Zutavern built a number of miniatures for *Spy Kids* — including an underwater cave and the castle headquarters of inventor/child show host/would-be world dominator Fegan Floop (Alan Cumming) — from his home garage-turned-model-shop. To save time and money down the road, Zutavern suggested constructing models first as very small-scale maquettes, only translating them into shooting-sized models when he and Towler had secured Rodriguez’s approvals. Upon approval, the team built the miniatures very quickly, without benefit of blueprints or construction drawings. “We would just put the maquettes on the table for reference,” said Zutavern, “and build the miniatures by eye.”

As a concession to the budget — and the size of Zutavern’s shop — even the final models were built at a very small scale. “All of the miniatures were designed and scaled to fit inside my two-car garage,” Zutavern stated. “That’s what determined the scale — that, and how high I could reach up with my hand. Except for the Floop’s castle miniature, which extended up through a hole in the ceiling of my garage, that was as tall as we went for anything. These models were probably the smallest scale I’ve worked in for a movie.”



Hybride produced approximately 80 percent of the first picture’s visual effects shots. The remaining 100 or so shots were farmed out to vendors such as Digital Anvil, digital.art.media and Digiscope. For a scene within Floop’s ‘virtual room,’ Digiscope – under visual effects supervisor Brad Kuehn – combined greenscreen elements of Daryl Sabara and Alan Cumming with digitally manipulated stock cloud footage.

Time and money were also conserved by waiting to shoot the models until after principal photography had been completed and Rodriguez had done a final edit on the live-action portions of his miniature sequences. “When it came time to shoot the miniatures,” Zutavern recalled, “Robert sent us video of all the shots; and we lined up and shot our miniatures to match. Most films shoot the models simultaneous to the principal photography; but what happens, inevitably, is that things change in the live-action, which means that the miniatures have to be reshot, and the prices keep going up and up. By waiting until Robert had shot and cut together his live-action plates, we could shoot only what we needed, from the specific angles and with the specific timings he’d worked out. It was a way to keep the budget down — which was necessary because this was probably the lowest budget I’ve had since I did a Roger Corman film 25 years ago!”



Near the end of Spy Kids, Floop’s duplicitous cohort, Minion (Tony Shalhoub), is subjected to the Floogle mutation process, resulting in his growing extra heads and hands – a makeup effect designed and executed by KNB EFX. Robert Rodriguez toyed with the notion of replacing the appliance’s fixed glass eyes with animated digital orbs, added in postproduction, but ultimately decided that moving eyeballs would be distracting for the audience.

All of the miniatures were shot at Image G, another small company which, accustomed to the fast pace of television work, was up to the challenge of limited time and money. The model photography crew clipped along at a pace of two motion control shots per day. “We’d set up a model at one end of the motion control track,” said Zutavern, “and another model at the other end; so while they were shooting at one end, we could be setting up on the other side. Then they’d turn the camera around, and shoot the other side while we were striking out the first model and bringing in another one. It went back and forth like that, which made it really fast.”

Image G and Zutavern even dispensed with motion control when a faster means of achieving a shot could be devised. For a shot of an airborne Carmen in a jetpack, crashing through a skylight, the crew merely dropped a small solid-cast Carmen puppet from the ceiling through a pipe, aimed toward an upside-down skylight model, and shot it high-speed. “We put someone up in the rafters with this little maquette,” Zutavern recalled, “and he just dropped it through the pipe; and then it came crashing out the other end, through the skylight model. The skylight miniature was made of candy glass and balsa wood; and underneath it was a bean-bag chair so the puppet would have something soft to crash into. We just kept gluing the candy glass back together and doing it again so we could give Robert a bunch of different takes to choose from.”

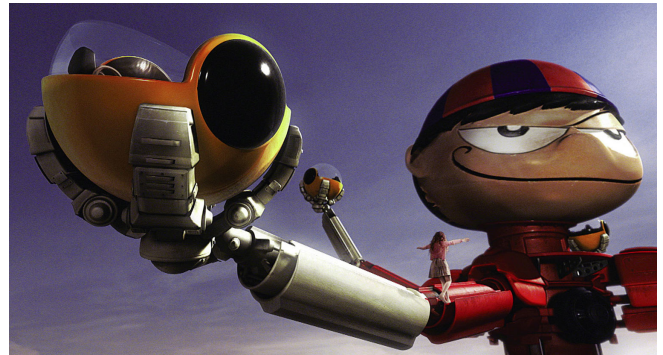
Quick-and-dirty miniature effects such as these had served *Spy Kids* well; but by the time Rodriguez began production on *Spy Kids 2*, he had decided to centralize even more of the work in Austin, relying on his local art department crew to build the models, and then shooting them himself as part of the ‘A’ schedule. Zutavern’s role became that of consultant, the miniature effects veteran flying to Austin for two days to instruct the modelmaking novices on detailing and other scale tricks of the trade.

Likewise, KNB, which had provided a large number of props and character makeups for the first film, made a smaller contribution to the second as Rodriguez relied more heavily on both his internal design crew and new technology. Whereas KNB had provided gadget props for *Spy Kids*, for example, Rodriguez had his art directors design the sequel's gadgets on the computer — a much faster methodology than designing with pen and paper. "Instead of having to draw stuff," Greg Nicotero said, "and then sculpt it and mold it, he would have guys drawing it on the computer and outputting it right into a CAD machine, which would provide wax pieces that could be molded individually. That's why *Spy Kids 2* is so much more gadget-heavy — Robert saw what he could accomplish and just how much he could accomplish in the computer."

Spy Kids 2 also saw an increase in digital effects, the bulk of which were again provided by Hybride. The company created 650 of the film's 1,000 effects shots, including the battle between the Spider-Ape and the Slizzard, 260 set extensions, all shots of R.A.L.P.H., the electronic bug, and the computer animated Thumb-thumbs that serve as Floop's clumsy, 'all-thumbs' henchmen. When the effects shot count grew to more than Daniel Leduc's crew could comfortably handle, Rodriguez farmed some of the work out to small companies in Southern California and Texas.

Among those small companies in California was Digiscope, which had successfully composited images for Floop's virtual room and a fireworks-above-the-Eiffel tower opening in the first *Spy Kids*. With Brad Kuehn supervising, the company worked on eighty shots for the sequel, including CG gadget enhancements and shots revealing the power of the cloaking transmoker device through 3D holographic images of earth and a violent volcano eruption. All 80 shots were completed in only eight weeks.

Computer Café, a ten-person company in Santa Maria, provided 40 shots of tiny computer generated animals, while five artists in the company's Santa Monica division, working under supervisor David Lombardi, completed the same number of shots for an encounter between Juni and sword-wielding skeletons. "Computer Café is not a big company," remarked Domenic DiGiorgio, "but all of the artists here are all-around artists. They can do modeling and texturing and animation. A big company has whole teams of animators and whole different teams of technical directors, and there are going to be times when one of those teams doesn't have enough to do. And there will be other times when that same team is so busy, they don't have enough people to do what's needed. Here, because everybody does a bit of everything, we can spread the workload throughout the company. From a cost and creative point of view, it's better because you have an artist who not only understands his little area, but also understands how that fits in down the track. So his work becomes much more efficient. Basically, we work the same way Robert does — he does a little bit of everything, and so do we."



The visual effects shot count for Spy Kids 2: The Island of Lost Dreams doubled that of the first film, requiring Rodriguez to enlist a number of vendors to augment Hybride's considerable slate of 650 shots. Reel FX Creative Studios was assigned 130 shots in the opening sequence, which has the president's daughter visiting an amusement park. Under visual effects supervisors Dale Carman and Brandon Oldenburg, Reel FX computer animated four fantasy-realm thrill rides – including the prominently featured Juggler – either modeling them entirely or adding CG appendages to existing structures filmed on location at Six Flags Over Texas.

Another modest-sized vendor brought into the Rodriguez fold for *Spy Kids 2* was Reel FX Creative Studios in Dallas, a nine-year-old computer effects company with a staff of 25, assigned 130 shots in the movie's amusement park opening sequence. Given a small budget and only three month's time, Reel FX computer generated four fantastic theme park rides: the Vomitor, the Nervewracker, the Whippersnapper and the Juggler. "Some of the challenges we faced were limited budget, short time frame and complicated shots," noted Brandon Oldenburg, who served as Reel FX's visual effects supervisor, along with Dale Carman. "But we have a concept we've coined here called 'working at the speed of thought.' One of the ways we do that is through our on-site effects compositing and editing system, Outpost, which allows us to go to a shoot and actually edit and do rough comps and run animations right on the spot." As a means of fleshing out theme park ride designs, Oldenburg, along with Carman and visual effects producer Chuck Peil, took Outpost to a site in Austin where Rodriguez was filming. "While he was shooting, I was working in the 3D software right there on the set, taking the design sketch he'd signed off on and roughing that out in 3D. In three hours, we were able to go from a sketch to a rough 3D drawing that was actually animated."



Using magnetic grippers, Juni climbs to the top of the Juggler to rescue the president's daughter, who has stranded herself there as a ploy to garner her father's attention. The principal action consisted of Daryl Sabara crawling across a horizontal set piece on a greenscreen stage. That element was then rotated to a vertical orientation and composited into a Six Flags plate.

“Outpost enabled us to use our time with Robert wisely,” added Dale Carman, “which was very important because, as the director, editor and the visual effects supervisor, it was hard to get time with him; so we had to take full advantage of the time we did get. On the positive side, having the director be the visual effects supervisor also meant that there was only one vision, one source of information for us to go on, one place to go to for a ‘yes’ or a ‘no.’”

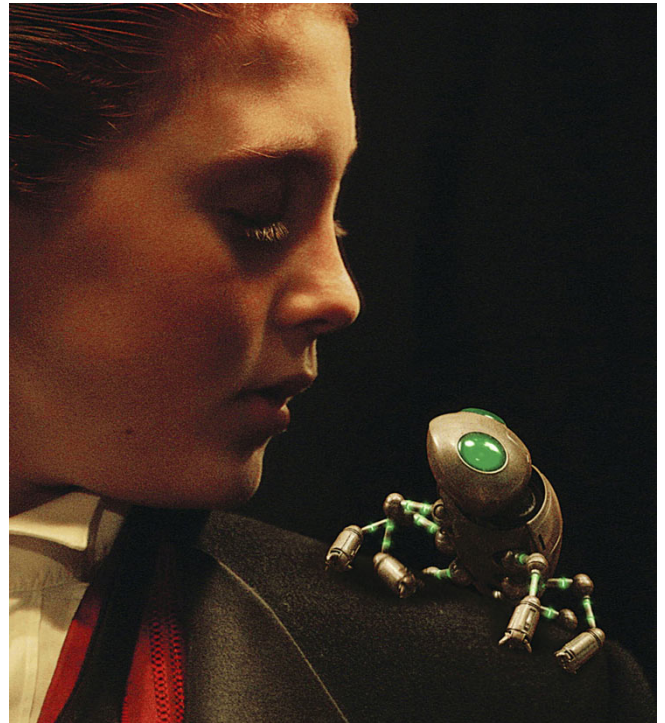
Another Dallas-based company, Janimation, created 30-plus shots of a two-headed sea monster that threatens Juni and Carmen as they float in the ocean near the island in inflatable suits. Generally staffed by ten people, Janimation ramped up to a whopping sixteen for the *Spy Kids 2* assignment. “I think the effects industry is taking a step backwards to the way things used to be done,” observed animation supervisor Greg Punchatz, “when smaller groups of people tackled larger jobs. During the nineties, when computers were first being introduced, there were more expenses because computers were so slow.

People built these million-dollar companies, all based on SGI technology, which became outdated so fast that they never even had a chance to pay those old computers off before they were done. And so some of those bigger shops had to close. Janimation is PC-based, which means we can spend the money on the talent, not on machinery that’s going to be outdated right away anyway.”

Small companies focusing on specific, well-planned digital effects enabled Rodriguez to realize all of his fantastic visions for *Spy Kids 2* quickly, efficiently and cost-effectively. “My mom used to say, ‘If you want to get something done, give it to a busy man,’” Rodriguez commented. “My effects people were all very busy; but they got their shots done quickly by focusing on one thing. And by not overworking the effects or blowing them up out of all proportion, they actually came out better.”

5. What an effects shot lacks in perfection, make up in style.

Mom’s good advice notwithstanding, not all of the effects could be tweaked and massaged to photorealistic perfection, given the constraints of time and money; and so Rodriguez went for a stylized look when necessary, rather than an ultra-realistic one. “I put more realism into the real sets and the acting,” Rodriguez noted, “and tried to ground the movies that way. I wanted the effects to be as realistic as possible, of course; but when they didn’t come out as real as I might have liked, I had to say, ‘That’s fine — that’s the style of the movie.’ Fortunately, the *Spy Kids* movies were not realistic movies anyway. If you’re doing a submarine movie and you have a CG submarine moving through your shot, it had better look completely real; otherwise the audience is pulled right out of the story. But these movies were fantastical, so I could get away with it.”



Juni confers with R.A.L.P.H., an electronic spybug that was digitally modeled by Alex Toader of Robert Rodriguez’s Troublemaker Digital Studios, then animated by Hybride.

Among the most stylized of the effects sequences in *Spy Kids 2* was Hybride's Spider-Ape/Slizzard battle near the end of the film. A long sequence featuring 100 computer animation shots, the creature battle was conceived as an homage to classic stop-motion animation effects. "We created computer textures that made the creatures look like rubber-model puppets," Rodriguez explained, "because I wanted them to have a very low-tech, Ray Harryhausen look. I knew I couldn't do *Jurassic Park*-type creatures with my budget, and I wanted more of a fantasy feeling to this sequence anyway, rather than a realistic look."

Hybride reinforced the low-tech style of the battle by reducing motion blur in the computer animation, giving it the jerky appearance of stop-motion. "I always liked those limitations that Harryhausen had," said Rodriguez, "because it gave his sequences a very dreamlike quality — and I wanted that feeling in this battle sequence. I wanted it so dreamlike that the characters might turn to the camera with a look that said: 'What the hell movie are we in? We're riding mutant creatures, fighting in the middle of an Aztec temple — how did this happen?' Up until then, everything was very tangible, and suddenly they were in this dreamlike sequence. But we could get away with it, especially with kids. I always believed that stuff when I was little, watching the Harryhausen movies. That style also made the Spider-Monkey character more likable and less scary, which I was always concerned about. During the design phase, we kept doing sculptures of him, trying to make him look less ugly and less scary, until we finally got him looking somewhat friendly. And then, as soon as we started animating him in this stop-motion style, he looked even more friendly. Maybe it was just because of my own attachment to those old stop-motion movies, but, to me, he seemed very disarming and likable — enough so that I didn't think kids would be scared by him."

6. Build as little set as possible.

Of all the old-style Hollywood filmmaking practices, none is more outdated — especially with today's digital tools — than the building of huge, finished sets. "Big sets aren't even that impressive on film," Rodriguez observed. "Big sets are only impressive in person. That's why studio executives visit their sets and think, 'My God, this is going to be the best movie ever!' But cup your hands around your eyes — which is all you're going to see because, no matter how wide your lens is, the camera never sees what your eye sees — and it's not that impressive anymore."

For *Spy Kids*, and even more so for *Spy Kids 2*, Rodriguez built as little set as he could get by with, which was not only an economical approach, but one that freed him to conceive ever more fantastic settings. The sets for *Spy Kids 2* were especially outlandish — such as the cavernous office of OSS director Donnagon (Mike Judge). "It was huge, like an arena," stated Rodriguez, "with chasms that Donnagon jumped across on giant moving columns.



On their approach to the mysterious 'island of dreams' in *Spy Kids 2*, Juni and Carmen wind up sea-bound, floating in overblown inflatable suits – built by KNB EFX – and harrassed by a two-headed sea serpent that was computer generated by Janimation in a series of shots supervised by animation director Greg Punchatz. Integrated practical and digital water elements simulated the creature's interaction with the water in the live-action plate.

But the only thing we built was his desk. On the greenscreen stage, we set up a series of apple boxes, covered in green, and had Mike Judge jump from one to another. So that was it — a desk and these green boxes. Nobody knew what was going on; but I had a picture in my head, and I knew the way to achieve it was not even to start putting up walls or set pieces. All the set was put in later, digitally. The main reason I started doing my own production design was because I realized so much of it was going to be done after shooting, there was very little to build — just things that were going to be tangibly touched or brushed against.”

The treasure room in the temple where Carmen and Juni find skeletons surrounded by jewels and golden idols also exemplified the minimalist set approach. Designed as a huge space, the entrance of which was the mouth of a skeletal head, the live-action part of the treasure room ultimately consisted of only two walls that the young actors acted against. “I shot the two walls and then flipped it for shots showing the other side of the room,” Rodriguez explained. “So the right side of the room was the flipped image of the left side — if you look closely, you can see that the treasure that is on the left is repeated, flopped, on the right side. I just contained the action within that small set. The advantages were that we didn’t spend a fortune building a huge set that the camera was never going to see, and it was easier to light.”



After landing on the island, Juni and Carmen encounter Romero (Steve Buscemi), a well-meaning mad scientist who has created a menagerie of miniaturized cross-bred animals such as a bull-frog, a sheep-dog, a tiger-shark and a cat-fish. Computer Café, under visual effects supervisor David Ebner and animation director Domenic DiGiorgio, created 40 shots of the bizarre CG characters. Among the biggest challenges was blending the disparate textures from one part of a hybrid’s body to another.

Cinesite extended the treasure room for wide establishing shots through a digital matte painting, added light effects and smoke, and blended those elements with shots of Juni and Carmen, using shortcuts whenever possible. “There were a lot of very similar angles in the treasure room sequence,” David Lingenfelter noted. “For example, for an angle on Carmen there were three different camera setups that made up 19 shots. So if we had a very tight shot on her face, we would pre-render out one background for 300 frames, with the painting and light effects and everything in it; and then we’d just bring that in and take certain chunks of it and reuse it for all of those tight shots, so we weren’t rebuilding the background for every shot.”

7. Take advantage of serendipitous filming opportunities.

More than one sequence in *Spy Kids* featured plates that Rodriguez captured at the spur of the moment, without preplanning or prior location scouting. For example, while flying by helicopter from one shooting site to another in Chile — one of the few *Spy Kids* locations outside of Texas — Rodriguez spotted a park in downtown Santiago that looked similar to the park in San Antonio he intended to use for a scene during the aerial jetpack chase through the city. Rodriguez recognized an opportunity to capture an unplanned background plate. “I thought I could get a cool aerial shot,” he recalled, “if we just flew over downtown real quick and shot it — hoping no one would get mad at us. I told the pilot: ‘Let’s just do a quick shot going towards this park, and then zoom down on

one of the statues there.’ So we did that, and I intercut that aerial shot with a statue in the park in San Antonio — and it looked like the whole park scene took place in the middle of Santiago.”



One of Rodriguez’s budget-conscious production techniques was to build only portions of his sets practically, film the actors interacting with those set pieces on a greenscreen stage, then composite the resulting elements into predominantly matte-painted environments. Cinesite, which produced 62 shots for the sequel, under the supervision of David Lingenfelter, painted in nearly all of the temple treasure room that Carmen and Juni discover on the island. A minimal foreground set, dressed with idols and jewels, was flopped to fill both left and right of frame.



For one of the film’s conscious homages to stop-motion master Ray Harryhausen, Rodriguez engaged Computer Café to create a sequence in which skeleton swordsmen attack Juni after he steals a precious artifact from the temple. Presented with an animatic of the 40-shot sequence – created by Rodriguez and his artists at Troublemaker Digital – Computer Café translated the Maya files to LightWave, cleaned up the computer animation, and completed the shots with lighting, texturing, rendering and compositing.

At another point in the jetpack chase, Carmen flies through a billboard, quickly followed by black Thumb-thumb shapes. Because the shots had been conceived as miniature effects, Lou Zutavern had already built the scaled billboard, mounted to the top of a generic-looking building. Zutavern rebuilt the model with a new building rooftop when Rodriguez shot more impromptu aerial backgrounds. “He was flying around in a rented helicopter, just scouting locations,” Zutavern said, “but he realized, ‘Hey, if I hang a camera out the window and shoot this stuff, I won’t have to come back!’ In that one week he was down in Chile scouting locations, he got all the background plates for the jetpack chase — he just shot everything himself.”

Earlier in preproduction, when consulting effects experts, Rodriguez had been told that the jetpack chase would require motion control filming. “I hung up from that conversation,” Rodriguez recalled, laughing, “and thought: ‘Motion control? There goes my budget. Okay — I’m not doing that.’ We never do any motion control or tracking — it’s all just sort of winging it. So I shot these aerial plates as smoothly as I could; and then I shot real smooth shots of the kids flying against greenscreen. I combined those, then put in the camera shake afterwards — and that worked fine.”

The same aerial location scout yielded another spur-of-the-moment plate, this one for a scene in which Gregorio and Ingrid, escaping counter-spies, drive their car off a winding road and into the ocean, where it transforms into a submarine-type craft. Rodriguez’s original thought was that he and his special effects crew would create the gag practically, with a real car being driven off a ramp and into a body of water. But he backed off the idea as he came to realize that its execution would be complicated, requiring divers and the laying of track. “It started becoming very involved,” stated Rodriguez, “and I thought, ‘Forget it.’

“Then, at one point, when I was up in the helicopter, I noticed the lighting was really nice; and I looked down and saw that there was a great road snaking around the coastline. I thought, ‘Hmm, that would be a good road for the parents to be driving on when they fly their car into the water.’ So I decided to just follow a car that was on the road. I would have to digitally replace it with the parent’s car later — but by shooting this car, we would have great lighting reference and we would know how the sun should hit the parents’ car and how the reflections would look. I told the pilot: ‘Let’s just pick a car and follow it — and then, at a bend in the road, pretend like it drove off into the water. The car will stay on the road, but move off of it as if it went into the water.’ And that’s what we ended up doing. The poor guy in the car was probably wondering, ‘What in the hell is this helicopter doing following me?’ But that took care of my car flying off into the water — I just did it digitally. I erased the real car as it made the turn and made it look like our digital replacement car



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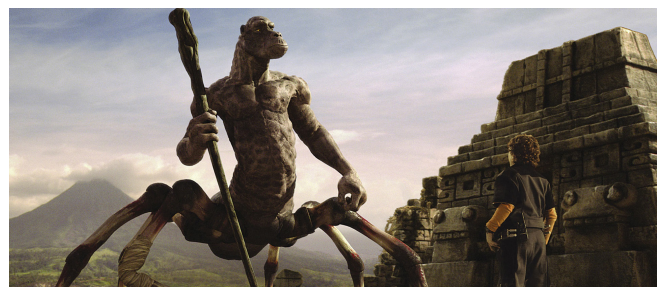
went sailing into the water. To have shot that for real, we would have had to coordinate helicopters and stuntmen and a car on tracks. This way, we did it in one take, just following a random car. That was another case of being able to make a snap decision because I knew what I could do later on with digital effects.”

8. Shoot in high-definition digital video.

Rodriguez has now completed two movies in high-definition digital video: *Once Upon a Time in Mexico*, the final chapter of his *El Mariachi* trilogy, due out in 2003, and *Spy Kids 2*. Having wholeheartedly embraced the format, he intends to use it for all his future projects, as well. Unlike most established film directors, for whom HD represents an unfamiliar new medium, Rodriguez views the technology as a happy return to his moviemaking roots. “I started with video,” explained Rodriguez, “because I couldn’t afford film, growing up. When I was twelve years old, I had access to my dad’s Super-8 camera; but when I shot some film, it cost me ten bucks to get two minutes’ worth processed — and half of that two minutes was out of focus because I couldn’t see what I was doing when I was shooting it. And on top of that, it was all grainy and the speed was weird.

“But my dad also had a video camera — a really early model that connected to the VCR by a twelve-foot-long cable, which meant that twelve feet was as far as I could move when I was filming my little movies. But with video, I could shoot for two hours; and if it was no good, I could erase it. Economically, it just seemed a much better way to do things. So I began entering contests and film festivals with my little short video movies. Later, when I finally got into film, I couldn’t believe how archaic it was! Everything slowed down to a crawl, and I couldn’t see what I was doing until I got the film back from processing. It felt like a huge step backwards; and I was really tired of it by the time I got to *Spy Kids*. We were filming with children and we’d just be getting somewhere with their performances — and we’d have to stop to reload. Then, for effects, we had to scan all of the film into the computer, remove the grain, composite in the effects shots and put the grain back in, and then spit it back out to film again — and the spit-out looked really degraded compared to the original negative. It was terrible. I would do a dissolve in the Avid and figure I was done — but no, I had to go see the filmout version of it. ‘Is that the right timing? It looks a little off.’ And they’d check it, and the timing was wrong, and I’d say, ‘Okay, do the timing like I did in the Avid.’ ‘Okay, now there’s a hair in there — is that hair on the print or on the new negative?’ ‘The B side is overexposed — is that on the negative they just made or is that on the print?’ I was doing everything three or four times — and the effects shots were even worse. By the time *Spy Kids* was done shooting, I was ready to blow up my film cameras.”

A new hope presented itself, appropriately enough, at Skywalker Ranch. While Rodriguez was mixing the sound for *Spy Kids* at Skywalker Sound, George Lucas invited him to check out the high-definition digital footage he had recently shot for Episode II of the *Star Wars* saga, *Attack of the Clones*. Impressed, Rodriguez decided to conduct his own test during *Spy Kids* reshoots, placing a digital video camera side-by-side with his film camera. “I wanted to see



In the course of his experiments, Romero inadvertently creates a hostile population of overgrown mutant beasts that escape on the island. In a classic stop-motion-style confrontation, the giant Spider-Monkey— which Juni has

how it would really look in comparison to film,” Rodriguez stated. “I didn’t want it to look like video. I didn’t want people to feel ripped off, as if they were watching a home movie. So I did this side-by-side test, just to see where the HD fell apart and didn’t look as rich — and I was shocked to see how bad the film looked compared to it. Even the HD that had been transferred to film — not projected digitally — looked better than the film. It represented much better what was actually on the set. On HD, I could see a side of the actor’s face that, on the film version, was just gone.”

be-friended — squares off against the Slizzard at the climax of the film. To help achieve a stop-motion look, digital artists at Hybrid modeled skin textures to resemble like the oversized Spider-Man, the Slizzard part snake, part lizard — was created by Hybrid in Softimage/XSI, which allowed artists to model, animate and render the creature all in one package. Creature animation was aided by data derived from a motion capture session in which the camera’s position relative to sets and props was recorded.

The test convinced Rodriguez to blow up those film cameras — if not literally, then figuratively — and he had made the switch to HD by the time he began shooting *Spy Kids 2*. His decision to go with the new format was validated immediately. “Film is so unpredictable,” Rodriguez remarked, “especially the way labs process stuff, you just don’t ever get what you had on the set. With HD, I was finally getting what I was seeing with my eye. And that meant I could light my shots more easily, and instantly see the results on the monitor. I could actually do much edgier lighting, without worrying about underexposing, because I could see right then and there, as I was shooting it, if it was underexposed. There was no getting the dailies back the next day and going: ‘Oh, guess what? We didn’t get that shot! Now we’re going to have to re-create that moment.’ HD allowed me to be more creative, because if something wasn’t working, I knew it immediately.”

9. Make everyone on the crew a hyphenate.

Veteran Troublemaker Studios crew members know that, like Rodriguez, they will be doing more than one job. “Everyone on my crew does multiple jobs,” Rodriguez remarked. “Everyone becomes one of those ‘slash’ people — set decorator/art director/whatever. I figure, I’m doing 50 jobs, so everybody else has to do at least three! But they are all excited about that. In fact, they don’t even want to work on other movies now. And if they do, they come back saying: ‘It’s unbelievable! No one wants to do anything, no one is excited — it’s such a drag!’ The way we work always feels like your first movie; and ask any director what his favorite movie experience was, he will probably say his first film when everybody did everything. Everyone pitching in — that’s the way it should be.”

Everyone is currently pitching in on *Spy Kids 3*, a highly anticipated, summer 2003 sequel that will no doubt further establish Robert Rodriguez as a big-time film director — albeit one who proudly espouses a small-time approach. “As I go on making movies,” Rodriguez concluded, “it becomes more and more like my experience on *El Mariachi*. I’m actually doing more jobs now than I did on *El Mariachi* because of effects and orchestral scoring and a lot of other things that movie didn’t have. But it is so much easier that way. In fact, the bigger the movies get, the easier it is to do more of it myself — because, really, they are only bigger in scope. They are actually smaller in budget and crew; and that is made possible by digital effects that enable me to attain my visuals in a much easier, faster way. Digital technology allows me to move at the speed of thought, to be creative and not be dragged down by the process.”

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Shaken & Stirred

ARTICLE BY CHRISTIAN CARVAJAL

New enemies and crises require a new kind of hero. In XXX, veteran National Security Agency honcho Augustus Gibbons, con fronted by a world of panic and terrorism, realizes his existing agents are insufficiently aggressive for the topsy-turvy, post-Soviet landscape. To combat this problem, he decides to recruit death-defying young upstarts from the fringe culture of extreme sports. There he finds a buff scofflaw named Xander Cage who — given a choice between jail and career heroism — agrees to travel to Prague and infiltrate Anarchy 99, a terrorist group headed by a sociopathic expatriate Russian named Yorgi.

Written by Rich Wilkes, XXX was conceived as a revolutionary new breed of spy action movie for the twenty-first century. Instead of a sweeping John Barry score, Xander Cage grooves on Rammstein and Orbital. He wears, not tuxedos and Savile Row suits, but ski togs and elaborate tattoos, the most distinctive and memorable of which is the blood-red 'XXX' emblazoned across the back of his neck. He drinks his vodka straight, no vermouth, and while he may have the same jones for cars as a certain British secret servant, Xander Cage is far more likely to drive a supercharged sports car off a bridge than park an Aston Martin sedan outside a casino.

Fresh from the success of their lucrative collaboration on *The Fast and the Furious*, director Rob Cohen and actor Vin Diesel accepted the challenge of bringing agent Triple X to life. To present Cage as a superspy for the new millennium, capable of outrageous feats of daring and athleticism, Cohen recruited popular extreme sportsmen such as pro skateboarder Tony Hawk and BMX rider Rick Thorne to serve as technical advisors and to appear as background characters and on-screen stunt performers. Though Diesel grew comfortable on snowboards and motorcycles throughout production — which spanned the globe from California to the Czech Republic to the island of Bora Bora — many of Cage's superhuman moves could only be performed by these highly-trained athletes or stuntmen. Closeups required state-of-the-art visual effects to put Diesel squarely in the middle of the explosive action.

The bulk of the film's effects assignment went to Digital Domain, under the supervision of Joel Hynek. Artists there collaborated with Syd Dutton of Illusion Arts on digital matte paintings that would establish and augment the many diverse locations around the world. Monitor burn-ins and other secondary effects went to Digiscope and Gray Matter.

Design of the effects sequences began as soon as Digital Domain came on the project, about a month and a half before the start of principal photography. "We were a part of production meetings and really worked as a team," stated visual effects producer Kelly L'Estrange. "We started with 114 shots; but by the time the movie was finished, we ended up with 327."

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ARTICLE BY CHRISTIAN CARVAJAL



When we first meet Xander Cage, he is commandeering a Corvette as a stunt for his online protest show, “The Xander Zone.” As Cage drives the stolen convertible toward the Foresthill Bridge near Sacramento, 728 feet over the American River, his ongoing commentary reveals his intention to punish the Corvette’s owner — an elitist senator who wants to ban violent video games — by driving the car off the bridge, then parachuting to safety as the car falls. The Corvette itself was a full-scale vehicle fitted by special effects supervisor John Frazier and his team; but putting Vin Diesel in that car as it plummeted from the bridge required a number of visual effects techniques. Even shots prior to the launch from the bridge, as Cage approaches a makeshift ramp, became visual effects shots due to Diesel’s unavailability the day the sequence was filmed. “They were shots the main unit could have easily done if Vin had been available on location,” Hynek commented, “but he was sick and had to leave the set early that day. So they shot some background plates, knowing we’d have to add to those plates in postproduction.”

Ultimately, those background plates were not used because of cloudy conditions at the location and camera movement that was less than dynamic. When the need for reshooting the sequence became apparent, Hynek suggested to Cohen that they shoot just the car against outdoor greenscreen, capturing elements that would eventually be composited into new location plates. “We ended up shooting that in the parking lot of the Los Angeles Zoo in Griffith Park,” Hynek said. “We were working on several setups at once, so we needed a big space. Our production supervisor, Peter Tobyansen, brought in shipping containers and stacked them into a wall, which we covered in greenscreen.”

John Frazier’s team mounted the car to an adjustable support rig in front of the greenscreen, and the cameras rolled as Diesel performed inside the vehicle. Freed from the restrictions of location filming, Cohen took advantage of the greenscreen setup and devised a number of dynamic camera moves on the spot. “After the greenscreen shoot was set up,” Hynek commented, “Rob realized he could move the camera any way he wanted.” To match the camera moves on the greenscreen element when shooting the new location backgrounds, Hynek and crew mounted tracking markers to the greenscreen. “Sven Gillberg, our data integration lead, tracked the greenscreen shot and gave us the parking lot camera move. We were worried about parallax and how much of the ground plane we would see, so we fed the shot into a motion control camera. We put that camera onto the back of a truck — a first for me — and I headed back to Sacramento to shoot new plates. We drove across the bridge to capture the new background plate, with the camera booming up and repeating the move from Griffith Park. Usually



In XXX— an action-espionage film from director Rob Cohen — the National Security Agency recruits extreme sportsman Xander Cage (Vin Diesel) as a secret agent for the new millennium. Though Diesel mastered basic snowboarding and motorcycle skills for the production, many of his character’s outrageous feats could only be performed by real-life extreme sportsmen. Visual effects from Digital Domain— supervised by Joel Hynek — put Diesel squarely in the middle of the action.



you shoot the plate and then the greenscreen; but in this case we shot the greenscreen first, then worried about reconstructing the background so it would match with regard to movement and lighting.” Appropriate bridge reflections were added to the hood of the Corvette in postproduction.

The movie opens with Xander Cage protesting a conservative congressman’s legislative agenda by stealing his Corvette, launching it off a bridge, and riding it, surf-style, before parachuting to safety. For wide shots, special effects supervisor John Frazier launched a Corvette and a live stuntman from a real bridge. Closer views were photographed greenscreen – with Vin Diesel riding atop a Corvette mockup mounted to an adjustable support rig – then composited into location bridge backgrounds by Digital Domain.



As part of a field proficiency test by his future employer, Cage is air-dropped onto a Colombian coca farm just as local narcotics agents launch an aerial raid on the drug compound. Rob Cohen and John Frazier block out the sequence on a tabletop miniature of the compound, built full-size north of Los Angeles and rigged with explosives and ramps to facilitate motorcycle stunts.

A similar greenscreen process was used to create the next shot — Diesel in profile as the Corvette's wheels make contact with the ramp. In a third process shot, Diesel is seen 'surfing' on top of the car as it plummets earthward and he prepares to unfurl his parachute.

At the bridge location, a stunt performer jumped from the plummeting Corvette, his escape captured by three *Crashcams* mounted to the vehicle, and fifteen ground-based cameras. The performer's face was then replaced with Diesel's. Though production had initially hoped to rely wholly on Diesel lifemasks worn by the stuntmen and athletes, the masks would prove unconvincing in medium and close shots, and Digital Domain was faced with replacing the stunt performers' heads with a computer generated model of the actor's distinctive dome for a number of shots — contributing to the increase in the final shot count.



Cage escapes the drug compound via motorcycle, leaping over a barn as helicopter gunfire ignites the structure. Fifteen cameras captured the action as a stunt rider jumped over the barn set rigged with massive pyrotechnic charges.

The process started with a cyberscan and numerous reference images of Diesel, the latter compiled early in production. "Cyber F/X did a full head and body cyberscan of Vin Diesel," related L'Estrange. "We scanned him in two outfits, one for a skiing sequence, and another for the climactic submarine sequence, with a full detail of the head. Then we took texture photos and mapped those onto the cyberscan data."

Digital Domain animated a head-replacement test during principal photography and sent it to Cohen, who was initially wary of the idea. "The head replacements were a big deal for us," said animation supervisor Brad Parker, "and they were a big deal for the director, as well. But he really got behind us after we sent him a DVD of our proof-of-concept. Rob took one look at the test, and from that point on, he got more and more excited about new possibilities for shooting stunt sequences. Instead of a very wide shot with a live-action stunt double falling, for example, or a really tight closeup with a blurred background, he could do mid-shots. He could shoot tight head shots of Vin Diesel doing the stunt with explosions going off behind him, or from inside the car while he's jumping off the back and pulling his parachute."

The CG head, modeled and animated in Maya, had to do more than just match the actor — in some cases, it had to look more like Vin Diesel than Vin Diesel. "There are some shots where, because of the angle or lighting, an actor is not instantly recognizable as himself," said Hynek. "But when we did a CG head, we had to make it very clear it was Vin — so we'd 'Vin him up.' We'd do the ideal Vin head, rather than the head you might actually see under those conditions. We also found that if we just slapped a head on, it was immediately apparent. We had to animate the head — even if it was only for a few frames and the animation was subtle — or the illusion fell apart."

Head shots went from Maya to RenderMan via M-TOR, a plug-in developed by Pixar and modified significantly by Digital Domain for the XXX project. At the rendering stage, the head's verisimilitude was achieved via a new skin shader written by Digital Domain technical director Brian Goldberg. "We rendered the heads in multiple subsurface scattering passes," Parker commented, "so we were able to split out passes for every computer generated light and give the compositors control over each of them separately. That way, if we needed one to be cooler, we wouldn't have to re-render on the CG front. Instead, we could relight it in Nuke, our proprietary compositing software. We could see and interact with this precomposite of what the head would look like; then, when it was rendered, it would automatically be split up. The shader in our render script would generate a folder for each pass and name it appropriately. That way the artist wasn't bogged down in naming conventions or any of those sorts of things. This was an intelligent shader in that it was not ray-traced. Instead, it was an approximation of ray-tracing based on one skin model."



Another jump during the drug raid sequence has Cage laying the bike on its side to sail cleanly between lines of wire fencing. As a safety precaution, the fenced area the stunt motorcyclist flew through on set consisted only of unconnected posts. After the fact, Digital Domain added CG barbed wire between the fence posts and rows of CG razor wire at the top, all of which shook convincingly as the motorcycle passed through. Because the stunt rider's head was clearly visible in the shot, Digital Domain replaced it with a computer generated Vin Diesel head – one of many head replacement effects executed for the film.

In a live-action gag orchestrated by John Frazier, the Corvette falls seven hundred feet to crash and explode on the banks of the river. "That was a great big wide shot," Hynek recollected, "and Rob was concerned that nobody would be able to see the car. So we rotoscoped the car out, enlarged it a hundred percent, and put it back in."

After his spectacular escape from the stolen Corvette, Cage parachutes gently to the ground. Diesel was lowered on a descender rig in front of the greenscreen setup, the action captured on Vistavision to allow for after-the-fact movement in frame. "We were able to take full advantage of the size of the frame by selecting motion within it," Hynek said. "That made it look as if the camera was shaking. Then we shot Vistavision footage of the bridge in Sacramento from an appropriate angle, through a telephoto lens, and added motion to that. Once the elements were composited together, it looked as if the cameraman was moving around under Vin, trying to stay under him as he came down."

NSA forces crash Cage's post-performance shindig and take him into custody. Rather than arrest and try him for grand theft auto, however, Gibbons (Samuel L. Jackson) offers to put Cage through special agent training of a most unorthodox kind. A cargo plane drops Triple X onto a Colombian coca farm, where he escapes death at the hands of a brutal drug lord, El Jefe (Danny Trejo), just as Colombian narcotics agents descend. The elaborate outdoor set was erected near Lake Piru, about an hour north of Los Angeles. The five helicopters circling the drug farm were real, as was the daring of Vin Diesel, who steered a motorcycle away from the advancing Hueys amid a barrage of pyrotechnic squib eruptions. The coca plants and outlying buildings in establishing matte shots,

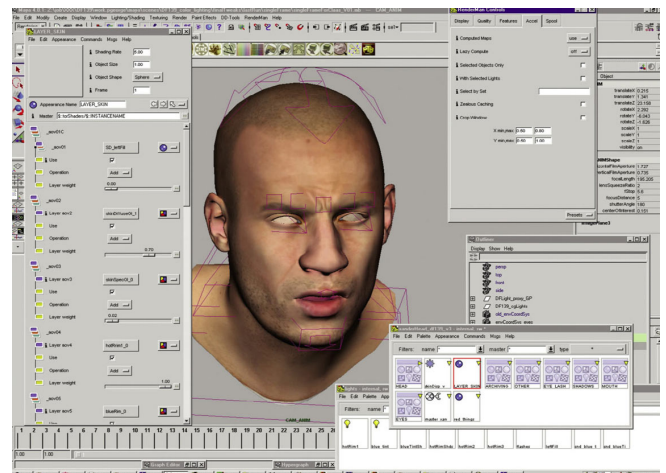
however, were added in postproduction. “We also removed articles visible in frame that should not have been in the scene,” related associate visual effects supervisor Matthew Butler, “such as a piece of the catering or grip truck. Those kinds of things can be difficult to spot at the time they’re captured on film.”

Believing Cage to be El Jefe, the Huey pilots pursue him with guns blazing red lines of hot tracer fire, all computer generated. “Rob left the look of the tracers to the executive producer, Arne Schmidt, because Arne had seen real tracer fire on other projects,” explained Hynek. “Rob just didn’t want it to look like *Star Wars* laser blasts. We walked a fine line between straight lines and hot, glowing core phenomena; and we tried to stay as consistent as possible with their look. Halfway through our tracer fire development, Arne decided we needed more; so we added 32 percent more bursts per second. Rob felt there should never be a tracer that didn’t do anything — he felt it was a cheat to have the tracers just go out of frame — so we had to make every tracer connect with something, either with practical bursts or little explosions we put in later. Claas Henke, our compositing supervisor, sometimes doubled them up so the same bullet hit would repeat; but it all went by so fast that the desired effect was achieved.”

To escape the aerial barrage, Cage seeks a way out of the drug compound, executing three motorcycle jumps of increasing difficulty. The first was done practically, as Diesel’s stunt double ramped over pyro-rigged bags of mock cocaine. The second required Cage to put his motorcycle into a tabletop maneuver, laying the bike on its side in midair to sail cleanly between lines of razor wire fencing. Throughout, Rob Cohen strove to justify the extreme athletic maneuvers of his lead character with logical situations and story points. “Why would Xander jump a motorcycle in this scene in this way?” queried CG supervisor Sean Faden. “Here was a great justification for that kind of showy move, because Cage could escape between two levels of razor wire by doing this outrageous tabletop stunt.”

As a safety precaution, the razor wire on the set was actually harmless stage wire, and the area of fencing that stunt motorcyclist Larry Linkogle jumped had only wooden posts with no wire strung between them. Digital Domain paraphernalia lead John Courte and lead compositor Jodi Campanaro added CG barbed wire between the posts and two rows of CG razor wire at the top — all of which reacted and shook convincingly as the motorcycle passed through. The fence posts were also extended digitally because Linkogle jumped too high when executing the stunt. “The fence post on stage was maybe twelve feet high, and the stuntman jumped fifteen feet high,” Faden explained. “But Rob wanted it to look like the motorcycle was slicing in between the razor wire, so we had to extend the existing fence posts before we added the CG wire.”

Initially, Linkogle planned on executing this and all other stunts without head-protective gear, in an effort to look more like the helmet-less Xander Cage. “But during a rehearsal,” Matthew Butler recalled, “while he was wearing a crash helmet, he hit his head on the helicopter that was supposed to be chasing him. I think that was the turning point. This was obviously very dangerous work, and everyone wanted to minimize the risk as much as possible; so we switched from what were generally meant to be in-camera shots with wide lenses to CG head replacement shots, including closeups. From that



Starting with a cyberscan and numerous reference images of Vin Diesel, Digital Domain modeled the CG head and

point on, the stuntmen almost always wore helmets.”

In the third motorcycle jump, Cage escapes the drug compound by using an overturned car as a ramp to the sloping roof of an outlying barn. Gunfire from the attacking Hueys ignites the barn in a spectacular explosion beneath Cage as his motorcycle carries him to relative safety. “The stuntman jumped over real pyro explosions in a practical barn,” stated Hynek. “At first we thought we’d compile the shot in separate passes of the stunt performer and exploding barn, but John Frazier looked at the setup and felt confident it was safe. Rob agreed, so they did it in one take with fifteen cameras rolling.” Postproduction digital paint work helped to make the practical ramp look more like a wrecked vehicle.

created subtle animations in Maya. A new skinshader written in-house enhanced the head’s verisimilitude at the render stage. Though Rob Cohen was initially wary of the approach, a proof-of-concept test convinced him that head replacements could be achieved convincingly, freeing him to shoot stunts at any camera range or angle.



Head replacement shots involved digitally painting out the stunt performer – who, most often, was wearing a bulky helmet – and tracking the CG Vin Diesel head to the stuntman’s headless shoulders. Background areas obscured by the large helmets had to be restored digitally. A moleskin cover for the helmets, which approximated the diffuse values of flesh, enabled the Digital Domain crew to capture appropriate interactive lighting in the live-action plate.

Because the rider's face was visible in the scene, the stuntman's head — with helmet — had to be replaced with the CG Diesel head. "The bulky helmet on the stuntman only intensified the problem," said Butler. The size of the helmet required that Digital Domain not only replace the stuntman's head with the Diesel head, but also create a CG T-shirt to cover areas previously eclipsed by the chinstrap and helmet. Areas of the background originally obscured by the helmet also had to be rebuilt by the CG crew.

Another difficulty presented by the helmet was that light did not interact with it at all as it would on Diesel's flesh. "We did not know we were going to do CG head replacements that first day on set," said Butler. "When we found out, we scrambled to create a moleskin cover for the helmet. Moleskin is a bandage material with a diffuse value somewhat close to skin, so it gave us an indication of how the lighting might affect real skin in that situation. It was tricky, because there was a lot of interactive lighting in that scene. We also added tracking markers to the moleskin cover, to aid us in tracking the CG head to the body."

After digitally removing the stuntman's head, Digital Domain artists utilized the company's proprietary tracking software, 3D Track, to track the CG head through the moving camera shots of the motorcycle jump. "We tracked the moving object," stated Sean Faden, "then handed the scene off to a Maya animator, who worked until the animation was spot-on. That animation was complicated by the fact that the helmet didn't bounce as much as an unhelmeted head might."

One shot's animation was particularly challenging because the computer generated Diesel head consumed nearly half the frame. "Not only did it have to read as Vin Diesel," commented Brad Parker, "it had to perform as Vin Diesel. There was no dialogue, but it had to grimace a bit. Also, it was an overcranked, slow-motion shot; and animating facial expressions by hand in slow-motion is a difficult thing to do." Compositor Sean Devereaux tweaked colors and lighting and 3D focus to finalize the barn-jump closeup — which featured 73 different CG layers on the head alone — working with Nuke scripts set up by character technical lead Darren Hendler to balance and composite all the various elements.



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Having passed Gibbons' coca farm test, Cage is given special agent status and an assignment of global import. The NSA believes Anarchy 99 has commissioned a lethal biotoxin and plans to spread the poison worldwide via a combination hydrofoil and submarine called the Ahab. From their home base in Vranov Castle in the Czech countryside, Yorgi (Marton Czokas) and his deranged comrades intend to launch the Ahab into the icy waters of the Vltava River.

To aid Cage in his mission, Gibbons introduces him to Agent Toby Lee Shavers (Michael Roof), an electronics and munitions expert who outfits the new secret agent with the latest in superspy technology. The snazziest item in Shavers' arsenal is a pair of multiple-wavelength binoculars, dubbed the 'Penetrator' for its ability to see through various substances. For a shot of Cage trying out the specs on a willowy Czech aviatrix, allowing him to see through her clothing, the local actress was scanned by Swen Gillberg at the nearest cyberscan facility, in Belgium. Brad Parker and his team used the cyberscan to generate skeletal models from scratch.

"The shot goes all the way through her in Penetrator mode and then comes halfway back," noted L'Estrange, "where we see the actress as half skeleton, half skin. So we shot a pass with her fully clothed, then a pass in her underclothing, and then a clean pass, and we mixed all three of those into the effect."

"The fun part about the shot, of course," added Hynek, "was to sneak in as much nudity as we could and still get a PG-13 rating. We also wanted a convincing x-ray effect. We had already done a test for the x-ray sequence in *Eraser*; and what we learned from that was that you have to make the depth of field extremely narrow, as if you're looking through a microscope. As you go out of focus on one plane, it disappears and is replaced by another. That allows us to isolate elements; because any time you do these x-ray gags, you're faced with the question: 'How far do we see? Do we see everything?' How do you make it convincing that he only sees the actress, and not this endless stack of background elements? So we minimized the depth of field; and as Triple X plays with the binoculars, he focuses on different objects in the space. It wasn't shot that way, of course. It was all done in post." Muscles and organs were also visible in the final Penetrator composites, which lead compositor David Stern completed in Flame to take advantage of its capabilities as a sixteen-bit design platform. A similar technique was used to realize later Penetrator shots of the Ahab submarine seen through a brick wall in Yorgi's riverside fortress.



Having passed the coca farm test, Cage is given special agent status. His first assignment is to infiltrate Anarchy 99, a Prague-based terrorist group headed by Russian expatriate Yorgi. Cage first meets Yorgi at a techno danceclub in which giant Tesla coils emit bolts of lightning – an electrical display created through digital effects. Cohen shot the scene at a decommissioned voltage testing facility in the Czech Republic. Digital Domain's integration team rebuilt the live set from survey data, allowing for interaction of the CG light pulses with digital set geometry. Atmospheric lighting and anamorphic lens flares were added to the final composites.

Cage first meets Yorgi at a techno dance club in which giant Tesla coils spray bolts of lightning across the ceiling. A digital solution was applied to create the electrical fireworks. “Technical director Hiroshi Tsubokawa created a system in which we could pick emanation and strike points,” Sean Faden stated, “but we also had an interactive pass in which the light pulses could interact with the set geometry our integration team had painstakingly rebuilt from survey data. If there was a sphere on the virtual set, Hiroshi would render the sphere with light interaction from the lightning bolts, so a cover pass could then be comped in. As the scene went on, we built our lightning to a crescendo, then let it die out as the camera tilted down. The director did not want lightning throughout the scene, as he felt it would be too distracting.” All the Tesla coil dance club shots were composited by Jodi Campanaro, who added general atmospheric lighting and anamorphic lens flares.

Thanks in part to a shared distrust of legitimate law enforcement, Yorgi accepts Cage as a kindred anarchic spirit and invites him to stay at his home base in Vranov. Digital matte paintings and other techniques were used to sandwich the historic edifice between snowy mountains and a tributary of the Vltava. “Vranov Castle isn’t in a particularly mountainous area,” Butler noted. “It’s in rolling hills, and it’s certainly not snowy. So we shot mountains in the Austrian Alps and the Sierra Buttes, plus river elements in the Czech Republic, and we used paint work to tile them all together into a collage. Some of the shots required a minimal amount of paint work, and others were fully painted at Illusion Arts. Joel and I shot everything from 2K JPEG stills to Vistavision plates to use as elements in those shots.”

Cage escapes with the information Gibbons needs, but the mission becomes more desperate when the new agent must return to Vranov Castle and disable the Ahab. To that end, he leaps from a Czech aircraft and sky-surfs into the mountains above Yorgi’s stronghold. Diesel was filmed on a gimbaled aircraft interior set, while stunt sky-boarders executed Cage’s wild descent, which included spins and flips. Upon Cage’s landing, wide shots of extreme snowboarders were intercut with closeups of Diesel captured against greenscreen at Griffith Park, the actor standing on a flexible platform to mimic snowboarding moves.

Pursued by Yorgi’s minions on all-terrain snowmobiles, Cage assays the unusual defensive gambit of triggering a devastating avalanche by tossing explosive charges over his shoulder. Though Diesel was really shot on a mountain for the scene, Cohen determined that the background area did not look sufficiently ‘pregnant’ — meaning excessively laden with snow — to foreshadow the avalanche that follows. Lead digital painter Shannan Burkley repainted the entire mountain, both in front of and behind Diesel, creating new background elements of the snow-covered mountain.



Convinced that Cage is a kindred anarchic spirit, Yorgi invites him to stay at his home base in Vranov Castle, a real-life historic edifice located in an area of rolling hills in the Czech Republic. To situate the castle between snowy mountains and a tributary of the Vltava River— as demanded by the story line — Joel Hynek and associate visual effects supervisor Matthew Butler shot plates in the Austrian Alps and the California Sierras, plus river elements in the vicinity of Prague. Illusion Arts matte artist Syd Dutton blended the disparate plates with painted elements, allowing compositors at Digital Domain to nestle the castle into a cohesive new environment.

Cage's exploding charges open cracks that extend in all directions. Animator Ryo Sakaguchi was largely responsible for the fissuring shots that initiate the avalanche. "Ryo wrote his own particle operators in Houdini," remarked Faden. "He used those to break apart a modeled subdivided snow surface into successively smaller pieces. The motion was generally subject to physics. We'd set the gravity and various points of interference and drag, and then we'd run the particle simulation, making slight hand-animated adjustments as needed post-simulation. He also had a separate crack influence map, because we didn't want as many cracks far away from the camera. If we subdivided the faraway terrain into small cracks, it looked too busy and noisy. So Ryo adjusted the shader to put most of the cracks in the foreground, where they'd be juicy and fun to look at. Once the pieces were only about a foot wide, we used animated displacement shaders to suggest subdivision into even smaller pieces."

Cage snowboards off the lip of the rapidly subdividing mountain, a shot that started with a location plate of a stunt snowboarder. "The snowboarder was tracked," Faden noted, "so we knew where he was. Ryo and Jonah Hall wrote a shader that used his board to generate an animated displacement map that spread out behind him as he moved. That left a gouge in the geometry, as if Xander were creating a board track in the snow." CG effects animator Robert Frick generated an additional snow wake to help tie Xander into the CG snow surface.

Cage then skis toward Vranov, only inches ahead of the cascading wall of ice and snow, a sequence that artfully blended greenscreen elements of the actor, live-action stunt plates and a computer generated avalanche. "Our general approach for the avalanche," commented Hynek, "was to shoot whatever the stuntman could do on location, then add the digital avalanche behind him, under him and around him. Wherever necessary, we also modified the terrain. At some points, we realized we had replaced everything in the shot, including our stunt skier."

Skies were also touched up in post to unify mountain slope plates shot all over the world, including wide vistas from the Austrian Alps, half-pipes in Mammoth, and rocky chutes in the Sierra Buttes near Lake Tahoe, California. Swen Gillberg's team shot reconstruction passes of each location from a helicopter, and then Digital Domain utilized its own integration software to reconstruct the terrain in 3D.

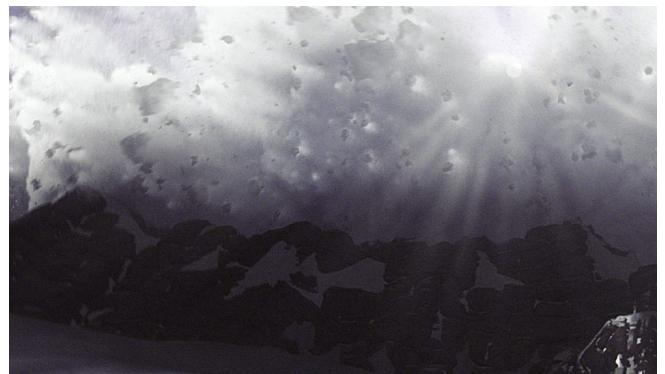
Rob Cohen had a clear vision for the look of the avalanche, describing it as a terrifying monster unleashed by Cage. "He wanted teeth," Faden said. "He wanted explosiveness. He wanted it to be like an animal." Under avalanche team lead Rob Stauffer, Digital Domain animators used storyboards and director feedback to previsualize the entire sequence, creating animatics for most of the key shots. What they soon discovered was that they were not designing just one avalanche, but many different ones, each with its own unique characteristics. "When we began, I thought we could develop a spectacular avalanche and plop it into every shot. As it turned out, though, it was more like we did 25 or 30 one-offs. Every shot was different. Either the terrain was so jagged that the avalanche wouldn't work on it, or the avalanche wouldn't do what we wanted it to do. In some shots the director wanted to see a lot of chunks, but in others he wanted to see more sloshing powder."

As the avalanche builds, it takes on several distinct features, which the avalanche team dubbed ‘tendrils,’ ‘billows,’ ‘splashes’ and ‘chunks,’ made possible through software — written and subsequently modified by technical lead Alan Kapler — called Voxel B, Digital Domain’s customized software module in Houdini. “Voxel B enabled Alan to create a system that broke the avalanche into volumetric components,” Faden explained. “In early versions of Voxel B, we basically rendered cloudy noise on grids; but the software was improved to allow us to create a volume and render it from any direction we want. It’s all rendered as one pass, giving us true volumetric shading and lighting. So if a tendril extended from the avalanche, for example, it would cast a shadow on everything behind or below it.”

The geometry of the avalanche was based on the location plate terrain. “We took the terrain model captured by the data integration team and re-created it using 3D Track or good old blood, sweat and tears,” Faden said. “Then we imported it into Houdini so we could animate a spline to approximate the leading edge of the avalanche. That leading edge would then birth particles, and those particles would form the billowy layer, which looked pretty cool by itself — but it wasn’t as exciting as Rob needed it to be.” Cohen’s more dynamic vision had the avalanche crashing against rocky outcroppings in its path. “Rob wanted an avalanche that looked even more threatening than a real one, with big chunks of ice and rock. Once we created the billowy information, we saved that to disk and set it aside for a bit. Then Alan created a terrain field, which he subdivided into various noisy colored regions, some of which acted like land mines. When the leading edge hit an area designated as rocky, we called that a bomb, and explosive blasts of particles would shoot out.”



As he snowboards down a perilous mountain slope, Cage tosses explosive charges over his shoulder, triggering a devastating avalanche intended to disrupt Yorgi’s minions, who are pursuing him on all-terrain snowmobiles. The lengthy avalanche sequence artfully blended greenscreen elements of Vin Diesel, live-action plates and stunt photography, and a computer generated avalanche. Initial post-blast fissures were achieved with a particle simulation that broke apart a CG-modeled snow surface into successively smaller pieces. Distinctive features that develop as the avalanche builds – billows, tendrils, splashes and chunks of snow and ice – were achieved through custom voxel software created by Digital Domain. Near the end of the sequence, Cage jumps to the top of a radio antenna as the killer avalanche smashes into Anarchy99’s communications center beneath him.



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The plumes arcing away from these explosive collision areas formed the distinctive tendrils. Each tendril, in turn, would arc into the terrain, its impact generating a splash. “We would create all the volumetrics for the tendrils,” Faden continued, “and then merge that with the billowy information to generate a 3D geometry on disk. The splashes were another volumetric element, so that got added to the disk information. When it came time for the final rendering, we would render all the data in one pass. Then we added the chunks of solid material thrown forward by the leading edge.”

The final result was an avalanche that was far more dynamic and threatening than the real thing. “There are aspects of our avalanche and reality that are identical,” said Butler, “but what’s different is the intensity. Also, ours could be choreographed to Rob’s satisfaction. Typically in a live-action avalanche, you’d see a lot of what Rob would call a ‘talc-fest,’ with only occasional tendrils and chunks. We took the artistic license to ramp up the ratio of chunks and tendrils to powder.”

Cage swerves between outcroppings to avoid the advancing avalanche, which looms over the nimble spy as he races toward Vranov. Cohen described this series of shots as ‘in the jaws.’ The design of the sequence changed from its initial concept. “Originally,” Hynek remarked, “it was supposed to mimic a surfing shot, with Vin actually surfing on top of the descending avalanche as if it were a wave on the ocean. At a certain point, Triple X would swerve between some rocks as the avalanche broke over them, and then he would surf inside the cresting avalanche like he was at Pipeline. Unfortunately, that original concept pushed credulity a bit too far; but we kept the idea of the avalanche smashing into rocks all around Triple X. We replaced some of the snow with rock, and the camera and stunt skier did a wilder move. Then we chose an angle that intensified the drama and worked better within the sequence.”

The original stunt plates were shot from the back of a snowmobile at a half-pipe in Squaw Valley. Matt Corder animated the avalanche for the final shot, basing avalanche behavior on Cohen’s directive to make it look threatening, yet ethereal. “Rob decided it should feel like a mouth rising up and chomping at Xander Cage,” Faden said. “We animated the wave to rear up and crash right behind him, then added plenty of ice chunks and splashes and smoky voxel clouds.”



Rob Cohen wanted the look and dynamics of the avalanche to suggest a savage beast whose jaws are just inches from closing around Cage. A typical shot in the sequence started with a live-action plate of a stunt snowboarder. After motion-tracking the shot, Digital Domain constructed a 3D terrain model from the location plates. Then a spline approximating the leading edge of the avalanche was animated. From that leading edge were birthed particles forming a volumetric billowy layer. Separate volumetrics created tendrils and chunks of snow

and ice, which were then merged with the billowy layer to form the avalanche. Rob Cohen wanted the look and dynamics of the avalanche to suggest a savage beast whose jaws are just inches from closing around Cage. A typical shot in the sequence started with a live-action plate of a stunt snowboarder. After motion-tracking the shot, Digital Domain constructed a 3D terrain model from the location plates. Then a spline approximating the leading edge of the avalanche was animated. From that leading edge were birthed particles forming a volumetric billowy layer. Separate volumetrics created tendrils and chunks of snow and ice, which were then merged with the billowy layer to form the avalanche.

Cage jumps to the relative safety of a radio tower as the avalanche and one of the snowmobiles smash into Anarchy 99's communications center beneath him — a miniature built and subsequently blown up by Digital Domain. "The only part of the avalanche that was not computer generated was an additional burst of snow that fell through a hole in the wall of the communications center as it exploded inward," Faden explained. "We shot glass microbeads and color-corrected them to use as snow elements in the avalanche collision." The microbeads, real crushed ice and water were shot on black sheets for a week in the Digital Domain parking lot, and were used as insert elements.

The 126 effects shots in the avalanche scene posed a number of challenges for the compositing team, such as having to rotoscope the stunt performer in the location plates in any shots in which the avalanche was to be seen behind him. "That was tricky," explained Claas Henke, "because he was so motion-blurred — and that motion-blurring would disappear if we roto-scoped him the traditional way. So we used software called Optiflow, which was developed in-house by Doug Roble. Optiflow tracks every pixel in an image, then outputs vectors we can use to reapply motion blur. In other words, it streaks the composite based on the directions things are moving within it."

Another challenge was the icy nature of the beast. "The director wanted more chunks than you would see in a real avalanche," Henke said, "and we had to see them through misty snow. They tended to look more like rocks or plastic than ice. By experimenting, we developed the technique of making the edges of the chunks slightly transparent, and then blurring whatever was behind them to make the ice look even icier."

Having survived the avalanche, Cage leads an armed assault on Yorgi's riverside hideout where the Ahab is being readied. Among the weapons deployed is a shoulder-mounted, heat-seeking missile launcher. Frazier flew a wire-rigged missile on set, but it proved ineffective. "It didn't have enough 'oomph' to make it all the way," L'Estrange noted. Digital Domain tracked a clean shot and added a CG missile and missile trail. A practical explosion marked the impact of the deadly missile.

Yorgi is killed in the ensuing conflict, but not before he has armed and launched the Ahab. The unmanned vessel enters the Vltava River from a hidden tunnel beneath the castle, with Anarchy 99's deadly biotoxins on board, and accelerates to cruising speed. To establish the castle layout and to make it clear how the Ahab is released, the camera tilts down from snowy mountains to Castle Vranov and then continues down the height of a rocky cliff to the tunnel opening as Ahab emerges and banks toward the city of Prague. "The tilt-down to the river included a photo collage," Butler

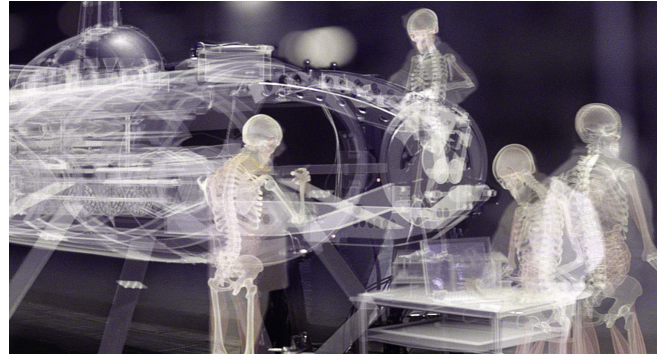
explained. “We shot part of that at Vranov and part at a nearby river, then added painted elements from Illusion Arts to the composite. It was a pseudo-2½D approach.”

With Ahab unleashed, Gibbons is forced to call in an air strike to destroy it, knowing it will save other cities and prevent a world war, but kill every man, woman and child in Prague — unless Cage can first intercept the hydrofoil and deactivate its payload. Legal and safety issues precluded a low-altitude flyover of Prague for the pre-attack approach. Instead, Matthew Butler shot Vistavision footage of MiG supersonic fighter jets from the roof of a control tower at a Czech military airbase. The jets were then split-screened into Prague plates, rotoscoped slightly as they dipped below the horizon beyond the river.

Meanwhile, Cage is in pursuit of the Ahab hydrofoil in a Pontiac GTO, impressively customized and armed by NSA technicians with flamethrowers, an ejection roof and missile launchers — practical modifications provided by John Frazier’s team. The physical effects team also built the 32-foot-long Ahab as two full-sized props, one designed to float on the surface of the water for static shots, the other mounted above a black platform fitted with a single outboard motor for full-motion shots. Both were shot from a platform camera boat that could cruise at 60 knots. Wings on the practical hydrofoil kicked up large side wakes that obstructed the vision of the Ahab driver, positioned in the back, out of sight. “There were communication issues,” remarked Butler, “because it was extremely noisy. The driver wore multiple wetsuits, but this was midwinter in Prague, so it was extremely wet and cold. On one shot, we had to cut early, because the Ahab hit the camera boat. It did not just drench us — it ripped off the speed rail and jettisoned one of the nose lances. Luckily, no one was hurt.”

The full-size props functioned as acting platforms for Vin Diesel, but were limited in that they could not execute the transition from passive, buoyant mode to full hydrofoil speed. To do this, it was necessary to create a digital Ahab model. “In hydrofoil mode,” Butler noted, “the struts become wings that generate enough lift to pop the main hull out of the water. Originally Rob wanted the Ahab to surge up out of the water and fly directly overhead, but we realized that would feel awkward because it would look like the craft severed our cameraman at the waterline. Instead, we redesigned the shot so the Ahab would seem to leap over the cameraman’s shoulder. We pushed it as close to the camera as possible so we could get a good view of the underbelly and even read the word ‘Ahab’ painted on its side.”

Digital Domain’s computer model of the Ahab, used for the transition shot, was based on a wire-frame generated at Revolution Studios. “The transitioning Ahab is CG, and most of the water in that shot is CG, as well,” commented Butler. “We shot a reference pass of the full-scale version of the Ahab, from which we grabbed the wake to split into our composites.” The CG model was also



The x-ray capabilities of NSA-issued super-binoculars allow Cage to see through the brick walls of Yorgi's riverside hideout as the anarchist's crew prepares to launch a submersible hydrofoil, Ahab, laden with lethal biotoxins intended to destroy millions of people and plunge the world into chaos and war. An extremely narrow depth of field allowed Digital Domain artists to isolate individual CG elements viewed through the binoculars as Cage adjusts their focus.

featured in the initial tilt-down from Vranov Castle to the craft escaping into the Vltava, and in shots revealing its relative position to Cage's speeding GTO as the Ahab approaches the Charles Bridge in the middle of Prague.

Because the Ahab is supposedly propelled by rear-mounted rocket engines that would kick up great volumes of water, Digital Domain shot water elements to be composited into the practical plates. "We set a pipe maybe six inches around and two feet long in our parking lot," explained Hynek. "We used it to eject fire hydrant water, with a lot of compressed air added to give it some froth. Then we added a little blue CG cone to the frothy water and comped it onto the full-size engines."

Additional CG work was required for shots in which the craft has already ascended from surface vehicle to its full-speed hydrofoil configuration — shots achieved with the motorized platform version of the practical Ahab. The outboard platform not only had to be removed digitally, something else had to be put in its place. Digital Domain stitched together water elements to fill in some of the now blank area. "In addition to the outboard motor we removed," said Butler, "we also had to remove a big wake that came off the back of the camera boat. So once we cleaned up the plates, we were missing a ton of stuff. We often stole water from the plate itself to stitch in. We had insufficient spray, so we had to introduce new spray elements." Digital artists extended the struts on the practical Ahab into convincing wings. "Any time you see the wings, you're seeing CG elements. There were a lot of those shots."

In a desperate move to destroy the Ahab and its lethal cargo, Cage uses a harpoon gun and descender-rig parasail to board the speeding vessel. Complicating matters, the Anarchy 99 toxins can only be neutralized safely underwater, and Cage has mere seconds remaining before the Ahab will launch its first missile and exterminate the unsuspecting citizens of Prague. He extracts the missile from its launch cradle and reinserts it upside-down, then



The unleashed Ahab makes its way down the Vltava River, toward Prague and its targeted citizenry. John Frazier mounted an Ahab mockup on an outboard-motor platform for shots of the hydrofoil skimming above the water surface. Digital Domain painted out the motor platform and its wake, then tracked in CG hydrofoil struts and stitched together water elements to restore painted-out areas of the frame. Practical and CG waterspray elements were also added.



The unleashed Ahab makes its way down the Vltava River, toward Prague and its targeted citizenry. John Frazier mounted an Ahab mockup on an outboard-motor platform for shots of the hydrofoil skimming above the water surface. Digital Domain painted out the motor platform and its wake, then tracked in CG hydrofoil struts and stitched together water elements to restore painted-out areas of the frame. Practical and CG waterspray elements were also added.

yanks the Ahab's hard drive from its motherboard just as the missile ignites. The inverted missile acts as a makeshift guidance rocket that shoves the Ahab deep underwater.

The craft's sudden submersion was set up as a greenscreen process shot in a water tank north of Los Angeles, using a Frazier Ahab mockup mounted on a strut that would collapse and dump the craft into the water on cue. Giant pumps underneath blasted water and air upwards at the Ahab as it hit the surface. "It shot up a huge spray," recalled Hynek, "which made the Ahab look really massive. I persuaded Rob to stage it that way rather than on a stunt Ahab that would dive all the way underwater. Not only would the spray be very dramatic, but it would allow us to cover any problems with additional spray."

Cage himself is tossed aside like a rag doll by the force of the sudden immersion. A stuntman performed the spectacular dismount in the tank, alongside the rigged Ahab mockup. "The stuntman was attached to a cable that yanked him off as the Ahab strut collapsed and all that water spray was launched," Hynek explained. "It was all done at one time; and then all we had to do was remove the cables, composite in the background and add some moving water in the foreground. We also added more spray around the stunt performer."

As Cage is thrown free, the missile engages, igniting the Ahab's climactic annihilation. "We were going for the kind of underwater explosion that causes the water around it to expand, then contract to refill the vacuum sphere," Hynek said. A miniature Ahab was constructed for the shot, the modelmakers relying on the CG and full-sized Ahabs for reference. "Alan Faucher did a marvelous job of building that model. We went for one-third scale, so our miniature was about eight feet long from the tip of the antenna to the tail. We shot it in Gene Warren's Fantasy II outdoor tank in Sun Valley, which was about a hundred feet across. Our pyro guy, Joe Viskocil, suggested the Fantasy II tank, because it had a sloping bottom and sides to help diffuse the shock wave."

To capture the distinctive, murky-looking water of the Vltava River, Cohen suggested putting spinach in the tank water, a trick he had used on a previous project, *Daylight*. The crew, however, was skeptical. "We were fairly timid on the first day of shooting," admitted Hynek, "and we only colored the tank water with cola syrup. But after running a test, Rob said: 'It's not murky enough. Come on, guys. Get some spinach, chop it up, and throw it in the water!' So we did. We bought cans and cans of chopped spinach, and threw it in there. It worked great. It was very murky."

Once Cohen was satisfied with the look of the tank water, the crew filmed the underwater explosion. The Ahab miniature was propelled down an underwater motion control track via a cable system powered by a topside motor, and was captured by two underwater cameramen shooting high-speed. "We were shooting 120 frames per second for the explosion shots," said Hynek. "The Ahab was supposed to be approaching camera, and we were trying to pan to it as it came out of the



Boarding the unmanned vessel, Cage extracts a missile from its launch cradle and reinserts it upside-down, causing it to act as a makeshift rocket that plunges the Ahab deep underwater. There the missile detonates, creating a huge explosion. A miniature Ahab was constructed for the scene, then shot in a large outdoor tank that featured a sloping bottom and sides to help attenuate the shockwave from the blast. To capture the murky look of the Vltava River, the crew added cans of chopped spinach to the tank water.

murk at us. On one of the shots, Pete Romano — one of the underwater cameramen — was standing on a ladder underwater; and as the Ahab came by, he fell off. That sent the camera through a sweeping rotation that really made it look like the Ahab was diving fast. It looked great, so we reviewed it on the video to see how he could repeat his mistake. That was the shot we ended up using.”

Joe Viskocil’s pyrotechnics blasted apart the underwater miniature — a case of a practical approach winning out over a digital one. “We’re pretty good at doing environmental effects at Digital Domain,” Matthew Butler commented, “but even so, the infinite detail inherent in reality is unmistakable. If you can do something for real, then I say do it — and this was one place where we could. Why make a special CG project for yourself, when a real underwater explosion gives you the interactive lighting and all that dynamic physical behavior?”

Having successfully completed his first mission, Cage takes his new paramour Yelena (Asia Argento) on a richly deserved vacation to the white sand beaches of Bora Bora. Only slight color corrections were needed to augment the natural beauty of the Polynesian paradise. Even the fish swimming around Cage and Yelena were present on location. Asylum Visual Effects twisted the final, idyllic shot into an aqueous pipeline that segued into the closing credits, complete with heavy metal soundtrack and such animated CG elements as a dragon, a skull and a souped-up Pontiac GTO engine.

The entirety of XXX was digitally color-timed by Efilm. “We always work toward even colors,” observed Claas Henke. “In the beginning, Jeff Kalmus, our color supervisor, color-graded everything to match, roughly speaking. Then we kept on fine-tuning it in the composites. We found one shot in a sequence that looked nice, and then we matched the other shots to that. The Efilm work helped us, though, because it meant we didn’t have to go all the way before we handed it off to them. We gave Efilm some shots quite late in the process, and they came through for us beautifully.”

XXX grossed more than \$140 million in its U.S. release, established Vin Diesel as an action star of the first magnitude, and once again confirmed Digital Domain’s reputation for first-rate visual effects, even in the face of a globe-trotting, breakneck-paced production. “It was a wild ride for us,” Kelly L’Estrange commented. “We did so much work in such a short time. All in all, we had only nine months to work on XXX, from boards to final prints. But not only did we get it all done, it looked great. I love it when good effects are used in the service of a good story, to tell you what’s happening to the actor or what adventure is coming next. The stunts and the effects in this movie boosted the audience’s willing suspension of disbelief.”



Model supervisor Alan Faucher and pyrotechnics supervisor Joe Viskocil ready the Ahab model for its underwater destruction. The miniature was propelled down a submerged motion control track via a motorized cable system, then blasted apart as underwater cameramen, shooting high-speed to enhance the sense of scale, captured the action.

“We’re always concerned about the excess factor,” added Joel Hynek, “meaning shots and sequences that take you out of reality to ask, ‘Is this even possible?’ For this project, it was important to keep the style of shooting as real as possible. It had to look as if someone could actually have been there and photographed it. What was interesting was that Rob’s approach to the shooting of XXX was similar to the movie itself. He was always trying to keep the work fun and exciting, always rushing to do one thing or another — and that sure made it feel like an action movie.”

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Middle-earth Strikes Back

image

ARTICLE BY JOE FORDHAM

Some years ago, New Line Cinema took a high-stakes gamble by greenlighting production of J.R.R. Tolkien's *The Lord of the Rings* trilogy. Odds were against the epic endeavor. The fifty-year-old literary masterpiece had defied earlier attempts to translate it to cinematic form, due to its long and involved story and its fantastic world and characters. Furthermore, the three-film production would require a tremendously sustained effort, spanning seven years from start to finish. And, finally, the whole project was to be in the hands of a director, Peter Jackson, and production and effects teams working halfway around the world, in Wellington, New Zealand. That gamble paid off handsomely when the first installment, *The Fellowship of the Ring*, released December 2001, was nominated for thirteen Academy Awards, won four, and brought in \$860 million worldwide.

The Fellowship of the Ring ended with a fellowship split and hopes for the fate of Middle-earth divided. The second film, *The Two Towers* — co-written by Jackson, Stephen Sinclair, Fran Walsh and Philippa Boyens — interweaves two plotlines played separately in Tolkien's novel. One follows Frodo (Elijah Wood) and Sam (Sean Astin) as they journey into Mordor to destroy the powerful One Ring that threatens all of Middle-earth. The other follows Merry (Dominic Monaghan) and Pippin (Billy Boyd) as they evade the clutches of mutant orcs and encounter a race of tree creatures, known as ents, who come to the aid of a deposed kingdom of men — reinforced by Aragorn (Viggo Mortensen), Gimli (John Rhys-Davies) and Legolas (Orlando Bloom) — in a last-stand battle against the burgeoning evil forces of Mordor. "By Tolkien's standards," Peter Jackson stated, "*The Two Towers* is quite a slender volume. It's not as complicated in its plot as *The Fellowship of the Ring*, so we added a few scenes and built a climax around Frodo and Sam. Of the three movies, I look on *The Two Towers* as the one where we deviated from the book, but only as enhancements."

The majority of shooting for the film had been completed in a fifteen-month principal photography schedule — overseen by producer Barrie M. Osborne — that began in October 1999 and ended in December 2000; but with Jackson's homegrown effects facilities, Weta Workshop and Weta Digital, busy with the physical and visual effects demands of *The Fellowship of the Ring*, postproduction on *The Two Towers* did not ramp up until November 2001.

Although Richard Taylor's Weta Workshop had delivered its main body of practical elements for the initial shoot — a five-pronged cavalcade of makeup effects, creatures, armor, weapons and miniatures — its design input continued throughout the new installment's postproduction, as did that of renowned Tolkien conceptual illustrator Alan Lee. Weta Digital producer Eileen Moran, meanwhile, added 120 staff members to the existing 230-person crew and implemented technical reinforcements. "By the end of Film One," visual effects supervisor Jim Rygiel recalled, "I was spread a little thin. I was sitting at a high-def monitor, going through composites morning to night, and I could not get away. I didn't have time to deal with shooting or discuss rendering, lighting and shading issues with the shader artists. So I suggested bringing in another person to help." Rygiel nominated Joe Letteri, who had first worked with him in the 1980s, and had since been employed at

Industrial Light & Magic as a shader artist, then visual effects supervisor. “Joe has great technical knowledge, but he’s also very creative. He became the visual effects supervisor for Weta Digital, while I worked for New Line and the production company, Three Foot Six.” Also joining the team at the production level was visual effects producer Dean Wright.

Weta ultimately produced approximately 800 visual effects shots for *The Two Towers*, including 600 animated shots, compared to *Fellowship*’s 100. When long-serving chief technical officer and digital systems architect Jon Labrie moved on to other fields of endeavor, Scott Houston stepped in to supervise the continuing upgrade of data processing power required to meet the technical demands of *The Two Towers*. “We more than quadrupled in size,” Houston related. “We brought in 1,200 new processors and 200 workstations. We more than tripled our online disk storage, from seven terabytes of data for *Fellowship* to approximately 25 terabytes for *Two Towers*. We commissioned two new computer rooms and moved part of the facility while we were in full production, running 24 hours a day, seven days a week. It was a hell of a roller-coaster ride.”

While Peter Jackson’s forces massed in Wellington, the creatures and people of Middle-earth braced themselves for their final stand against two towers of evil — the Dark Lord Sauron, in his citadel of Barad’dûr; and his accomplice, Saruman, in his fortress at Orthanc in the now-deforested valley of Isengard. The true fate of Middle-earth, however, weighed on the hobbits venturing into Mordor, pursued by a wheezing, lisping creature that followed their every step.

The Two Towers opens with an aerial shot over snow-topped peaks that spirals downward until the camera crashes through a mountainside into the mines of Moria, where Gandalf (Ian McKellen) and the Balrog are plunging into cavernous depths— as they were when last seen in *The Fellowship of the Ring*. Sony Pictures Imageworks composited the shot — one of approximately 100 subcontracted to it — blending an alpine plate captured on New Zealand’s south island with Weta’s CG Balrog character and miniature environment. The sequence continues as Gandalf plummets, clinging to the titanic, bat-winged creature as it falls through three miles of volcanic cavern, smashing against cave walls and erupting with fire.

The extreme speed and confined space dictated a digital approach to modeling the cavern. Weta digital environments supervisor Gray Horsfield — who generated CG Balrog fire effects in *Fellowship* — modeled the cavern by extracting displacement maps from laser scans of rock textures used in the miniature cave sets and geological samples from the Wellington Botanical Gardens. Gandalf’s digital double stood in for McKellen for two-thirds of the sequence, interspersed with live-action closeups of the actor. “We prevized camera moves early on,” said Horsfield. “We shot Sir Ian on a mechanical bucking bronco, which was quite funny. We put the camera on a motion control rig and went racing by him, so that he appeared to be flying right by us. We then made three transitions to digital doubles. It was very tricky to get the dynamics on his cloak to match as he was falling.”

Animated by Andrew Finlay, Matt Logue, Carlos Rosas and Adam Valdez, the Balrog receives severe lacerations during the fall, its skin ripping open and bursting forth fire. As he had on Fellowship, Horsfield animated fire effects through the use of 'sprites,' projecting practical flame effects onto CG cards, then animating the cards as particles. Physical effects supervisor Stephen Ingram and NZFX Limited crew member Scott Harens created the live pyro elements with compositor Alfred Murre — blowing jets of flame over nonflammable 'former' shapes as multiple cameras recorded the action at 150 frames per second — allowing Horsfield to project sprites from alternate angles as they animated through the shot. To simulate lava-like secretions seeping from the Balrog's skin, Ingram and Harens piped high-pressure gas into a concrete ember pot filled with napalm, inserted a conical former, then quickly squeezed the burning ooze through a covering of blackwrap.

Weta Digital animated an unfurling sheet of flapping fire, utilizing an adaptation of hair simulation software written by Jeff Hameluck. "We wrote a shader to make fur look like fire," explained Horsfield. "As the Balrog fell and tumbled, we animated fur to stream from cracks in his arms and back, fluttering as he turned. Then we made it glow. That led into particle streaks as chunks flew off in sprays of sparks. Those were low-level sprites. We then added higher-detail sprites for big unfurling, blooming flames, with explosions, trailing fire and heaps of smoke."

The Balrog and Gandalf plunge from the narrow cavern and, for a heart-stopping moment, are revealed in scale, glowing like a tiny firefly, as they fall into a cave containing a subterranean lake — the Foundations of Stone. Director of miniatures and visual effects photography Alex Funke and his team photographed a ceiling of miniature stalactites, illuminated with interactive lighting in multiplane-style layers. They then shot a less-detailed floor element hung from above. Compositors assembled elements with a far background painting.

After a four-frame splashdown, animated with water sprite elements, the scene shifts dramatically to Frodo, who wakes startled from his seeming nightmare, yelling Gandalf's name. Frodo and Sam then continue their journey toward Mordor, scaling the craggy terrain of Eryn Mui — shot on location at Mount Ruapehu in Tongariro National Park, north of Wellington. "We extended that environment so it looked like they were really lost and could go on climbing for days," noted senior matte artist Yanick Dusseault. "We went back out to Mount Ruapehu very early one morning and stayed there until sunset, shooting digital stills and video, studying what happened to the light at that high altitude. We utilized those images as a texture base, massaged the images together with matte painting, and projected those elements onto 3D geometry. We then re-created the environment with a dimensional camera move." For shots of the hobbits using an elven rope to



After the critical and box office success of The Fellowship of the Ring— the first in a trilogy of films based on J.R.R. Tolkien's The Lord of the Rings— director Peter Jackson continued the quest with artists and technicians at Weta Workshop and Weta Digital in New Zealand. The second installment, The Two Towers, built upon a foundation of practical and digital effects resources laid down in the first film's production and featured approximately 800 visual effects shots, including 45 minutes of character animation.

descend a cliff face, Stephen Ingram and his NZFX team supported the actors from an overhead cable rig on an interior soundstage set. Rocks were later composited below.

When Frodo and Sam stop to rest, the creature who has been following them seizes the opportunity to move in, its gaze fixed on the Ring hanging from a chain around Frodo's neck. Seen from a high angle, looking down on the sleeping hobbits, the pallid, almost naked, skin-and-bones figure descends head first, bony fingers clinging to the rocks, creeping like a spider.

Of all the many creatures created for *The Lord of the Rings*, none was the source of more trepidation and concern than Gollum. "We were very aware that everyone who had read the book had a strong preconceived idea of what Gollum should look like," noted Richard Taylor. "Gollum is one of the most iconic and loved folklore images of the twentieth century. To be tasked with the job of designing the definitive, quintessential fantasy character from our literary past was tough."

Taylor's team produced hundreds of drawings and more than 100 clay maquettes to explore Gollum design, and also addressed the broader issues of how to bring the character to life. Puppetry was rejected due to the restrictions it imposed on shooting. Taylor considered creating Gollum as a makeup, using computer graphics to enlarge the character's eyes and elongate his limbs; but Peter Jackson feared a makeup effect would prove disappointing. "Gollum was so emaciated and twisted," Jackson said, "walking on all fours, scrambling up and down cliff faces — it just wasn't conceivable that we could have done that with a human. So we made the big decision early on to create Gollum as a CG character, using a combination of animation techniques."

The decision fulfilled a long-held ambition of animation supervisor Randall William Cook. "When I first read *The Lord of the Rings* as a teen," said Cook "I thought it could be the greatest Harryhausen movie ever; so I was excited at the notion of creating Gollum as an animated character. Certainly we've seen animated characters integrated with live-action before, all the way from *The Ghost of Slumber Mountain*, through *King Kong*, the Harryhausen films and notable efforts at Warner's, MGM and Disney, into the computer era. The difference with Gollum was, instead of simply showing up and performing a star turn, a synthetic character of great complexity was required to interact with humans and display a significant emotional range with a sustained, intense and intricately shaded performance."



Plunging viewers immediately into the action, The Two Towers opens with a descent into the mines of Moria, where the wizard Gandalf (Ian McKellen) was last seen falling into an abyssal trench with the fiery, bat-winged Balrog. McKellen performed closeups astride a bluescreen Balrog rig. Wider shots featured the actor's digital double grappling with a digital Balrog, which combined CG geometry with practical and digital fire simulations. Weta modeled five miles of CG cavern for the scene, using textures extracted from laser scans of practical geological samples and miniature cave sets.

As Gollum designs evolved, sculptors Jamie Beswarick and Mike Asquith produced expression studies and a full-scale maquette. To incorporate greater surface detail than what could be achieved in real scale, the Workshop team also produced a double-scale maquette. Artists scanned the full-size maquette with a handheld digital scanner, pared down the CG surface by a five-millimeter skin thickness, divided the model into 600 cross-sectional slices, and printed them with a central registration point. Then they photocopied printouts at the required magnification, spray-glued them to urethane foam, milled out shapes with registration holes, and slipped the Gollum slices onto a plastic frame, rebuilding the body. Sculptors painted a thin layer of molten clay onto the urethane form, pressed five-millimeter-thick sheets of modeling clay onto it, then sculpted in fine detail. “It sounds very time-consuming, but it was actually very quick,” observed Taylor. “In a matter of days we had an exactly proportioned, scaled-up re-creation of the original.”

Scans of the Gollum maquette became the basis for the Weta Digital 3D modeling team’s work, as well. “We scaled him down to about three-quarters the size of the physical maquette,” said digital model supervisor Matt Aitken, “so he was approximately four feet tall. We did a lot of cleanup work on the detail point cloud of the maquette, preserving all the gorgeous detail in a high-rez model. We then produced a low-rez version, which is the version of Gollum that was animated, skinned, lit and rendered. We were able to extract a lot of sculpted detail as displacement maps by comparing the difference between the high-rez and the low-rez models. We could then restore that detail at render time using those extracted displacement maps. We used that technique for our tests in order to show New Line that Weta could do the job.”

The Gollum proof-of-concept test for New Line Cinema president Robert Shaye featured the character climbing over a rocky cliff as he approached a sleeping Sam and Frodo — a scene that was originally key-frame-animated by Randy Cook. Adam Valdez, who served as animation supervisor on Fellowship and senior animator on *The Two Towers*, also animated an emotional lip-sync scene to prove Gollum’s acting chops.

Principal photography had been underway for several months when New Line approved Gollum’s digital screen test. Gollum would be an entirely computer generated character; but though Jackson had rejected the notion of a human actor in a suit, he still wanted the performance to be human-based. “I wanted a human actor in charge of the CG character,” Jackson explained. “So many animators



En route to Mordor, where they hope to destroy the all-powerful One Ring, hobbit heroes Frodo Baggins (Elijah Wood) and Samwise Gamgee (Sean Astin) are stalked by Gollum, a 500-year-old creature consumed by a desire to possess the Ring. After five years’ development at Weta Workshop and Weta Digital, and a brief appearance as a shadowy presence in The Fellowship of the Ring, Gollum stepped into the limelight for the Two Towers as a digitally animated leading player with significant psychological range.



and shader writers get involved in a CG character, I was worried Gollum would end up not being as centered a character as we needed.”

What Jackson proposed was shooting scenes with an actor portraying Gollum present. An on-set Gollum would not only encourage interaction and an emotional connection between the characters, it would also provide crucial reference for the lighting and animation teams. Andy Serkis was cast after early auditions in London, and had a profound impact on the characterization of Gollum. “Peter became very excited by Andy’s performance,” Cook remarked. “He gave us a tape of Andy’s first audition, and said, ‘Here’s Gollum!’ — and it was the character vocally, fully-formed. From that point on, Peter wanted to take Gollum away from a degenerate amphibian into a degenerate Andy Serkis. This kept Gollum in thematic sympathy with Tolkien, and also helped us keep the character based on a real-world naturalism, rather than simply stating that the Ring turned Gollum into a monster. Andy’s take on Gollum was that the Ring had become an addiction.”

Serkis’ performance also inspired a scene that provided insight into Gollum’s origins. “Back in our original shooting period,” recalled Jackson, “while Andy was performing Gollum scenes, Fran had suggested showing Andy as Sméagol, Gollum’s original persona, when he finds the Ring. I thought it was a great idea; so we pulled a small crew together and, while Andy had some time off from the main shoot, he went off with Fran and they shot this amazing sequence.” The episode showed Sméagol fishing with his cousin Déagol, both members of a primitive breed of hobbit, their look achieved with subtle Weta Workshop prosthetics. Déagol accidentally dredges a mysterious ring from the riverbed, then falls prey to his cousin’s overwhelming desire to possess the object. “It was an incredibly potent sequence; but it was quite long, lasting about five minutes. Rather than cut it down to almost nothing — we thought it should either be there, in its entirety, or not at all — we decided to cut it from *The Two Towers*. It will now appear in *The Return of the King*.”

Serkis provided animation reference of Gollum in his fully transformed state by performing in a form-fitting unitard that covered his entire head and body. Weta Workshop hand-painted the unitard to approximate Gollum’s skin tone as a means of providing lighting reference for the CG model in live environments. Dubbed the ‘gimp suit’ because of its resemblance to an S&M getup, the unitard became a source of consternation for Richard Taylor and the animators at Weta Digital. “We made a terrible mistake with the gimp suit,” Taylor confessed. “We wanted to control the flapping of Andy’s hair to make it easier to rotoscope him from background plates, so we put his head in this full hood and cut a mouth-hole and eyeholes so that he could see. Months later, when it became apparent what an inspiration Andy was for the animation of Gollum, it was a bitter disappointment to have his face covered. There in the living flesh, shot-by-shot, was the actor performing the very animation that we needed — and we couldn’t see it because it was hidden by this bloody mask!”

Weta Workshop designer Richard Taylor and supervisor of Gollum’s digital creation, Peter Jackson, had a close relationship. Jackson’s idea of having an actor in a form-fitting unitard to provide lighting reference for the CG model was a brilliant one. The actor, Andy Serkis, was a perfect fit for the role. Serkis’ performance was a key factor in the creation of Gollum. The actor’s physicality and emotional connection to the character were essential to the success of the animation. The actor’s performance was a key factor in the creation of Gollum. The actor’s physicality and emotional connection to the character were essential to the success of the animation. The actor’s performance was a key factor in the creation of Gollum. The actor’s physicality and emotional connection to the character were essential to the success of the animation.

Visual effects cinematographer Brian Van't Hul and his digital camera department organized the multitude of Gollum shots and provided crucial data for Gollum animators and technical directors. "In many Gollum scenes, we used what we referred to as 'rotomation,'" noted Van't Hul. "One of our technical directors, Tim McCallum, created an Andy-Serkis-shaped digital puppet in Maya using human geometry rotoscoped from Andy. We did 3D Equalizer matchmoves, which gave us a geometric grid laid over the ground, then we matched our Andy puppet to Andy's motion in the gimp suit to make sure all of our perspectives were correct. People questioned why we bothered creating an Andy puppet when it was supposed to be Gollum in the final shot, but the matchmove was so critical we really wanted to retain Andy's information. Gollum's proportions were so different from Andy's that it became very arbitrary where his elbows and limbs should go. So we started with our Andy puppet, invisibly linked that to a 3D Gollum puppet, and had a switch so we could flip between them. We then did whatever little tweaks were needed to fit Gollum to the plate."

Once the CG camera department set up geometry and matchmove data for the scenes, it made the information available to the rest of Weta Digital in an online database. The animation department then addressed performance, while technical directors addressed shader and lighting issues. "We had so many Gollum shots we found it really helped if we could start all departments working on a shot simultaneously," said Van't Hul. "As soon as animation was done, lighting would be set and we could start rendering. For over-the-shoulder shots tight on the back of Gollum's head, we were even able to bypass animation and go directly to lighting. In those cases, the animation was pretty much just Andy."

By the time Weta Digital geared up for these postproduction tasks for *The Two Towers*, the six shots of Gollum in *The Fellowship of the Ring* — designed as a teaser to his more prominent appearance in the sequel — no longer reflected the shifting attitude towards the character and his motivation. “We realized it was going to be imperative to make Gollum much more tightly aligned to Andy Serkis,” observed Richard Taylor. “We needed a natural progression from Sméagol through to Gollum, from the live-action actor through to the digital model; and so a whole new level of design started, this time driven by the sculpting of Jamie Beswarick and a sketch by Christian Rivers.”

A key designer on *The Lord of the Rings* trilogy, Rivers produced a Photoshop layout juxtaposing a head-shot of Serkis as Sméagol between two drawings in the same pose — one of the existing Gollum head and the other subtly combining Serkis’ features. “Pete bought into it right away,” said Matt Aitken. “In our first model of Gollum, the eyes were bigger and the head was more ‘froggy’ — but we didn’t really get a good look at that in *Fellowship*, so we decided we could change it.”

The Gollum redesign immediately impacted creature facial lead Bay Raitt, who by then had invested two years’ labor developing the creature’s facial animation system. “There are two ways to animate faces,” stated Raitt. “One is to create a simulation that involves building the skeleton and the muscles in the face, then driving the expressions programmatically. The other is a sculptural approach, where you sculpt every possible combination of muscle shapes in a computer, and then an animator selects those and animates between them. We ended up taking the sculptural route, fortunately. We would have been up a creek if we went the other route, since Randy and Peter tended to ask for combinations of expressions that were impossible to simulate.”



Andy Serkis performed Gollum’s scenes throughout the main-unit shoot, providing not only the CG character’s voice but also crucial physical and emotional interaction with fellow actors on set. Serkis’ spirited portrayal had a significant influence on the creature’s look, behavior and personality, and led Peter Jackson to enhance Gollum’s role. During post on *The Two Towers*, Serkis donned a sensor suit to re-create many of the creature’s scenes on the Weta Digital motion capture stage.

The sculptural approach placed an almost limitless range of facial expressions in the animators' hands, constrained only by anatomy. To help delineate poses, Raitt researched the history of facial deconstruction. "We found a book called *Facial Expression* by Gary Faigin," said Raitt. "Paul Ekman, who is a professor of psychology at the University of California — *San Francisco*, and teaches interpersonal perception, also did some interesting work breaking down the face into 'action units' of neurological and muscular combinations. Randy turned me on to an Austrian sculptor, Franz Messerschmidt, who sculpted facial expressions in lead, and eventually died of lead poisoning; and we looked at old photographs of extreme expressions produced when French asylum workers jammed electrodes into patients' faces, which were very disturbing."



Andy Serkis, clad in a form-fitting unitard to provide a clean silhouette of his movements, performs a reference take as Gollum, wrestling with Frodo and Sam for possession of the One Ring. The unitard – dubbed the 'gimp suit' for its resemblance to S&M attire – proved invaluable for Weta Digital, which placed Gollum into rough-and-tumble shots by tracking gimp-suit actions and linking them to a 3D Andy Serkis puppet. Animators crafted the performance of the final digital character by combining Serkis' natural body movements with key-frame animation.



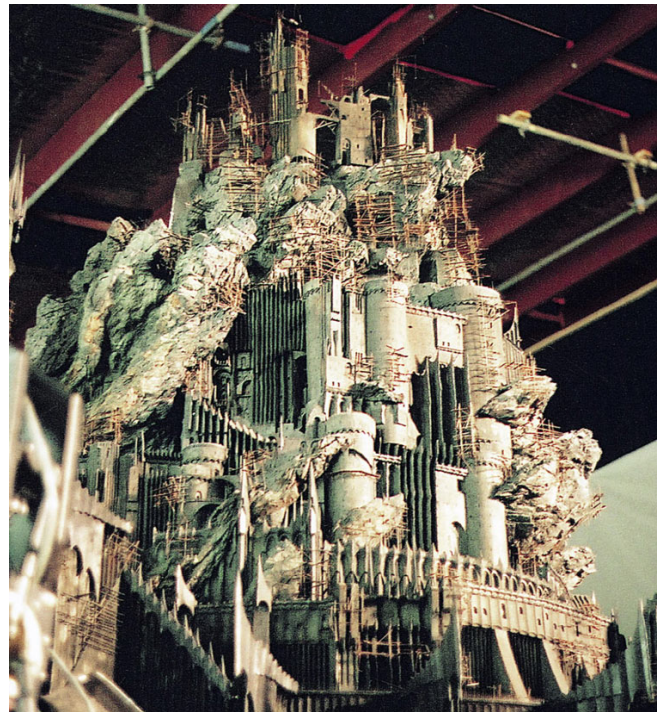
To digitally remove Serkis from production plates, compositors cut-and-pasted areas of the frame from clean motion control passes, when available. Gollum's wiry physique – radically thinner and more gangly than Serkis' – revealed more than the actor occluded in the frame and often required compositors to make creative use of still frames culled from alternate takes as a means of restoring backgrounds. Physical effects provided interactive dust,

which further reinforced the illusion of Gollum's frantic, flailing figure interacting with the live-action environment.

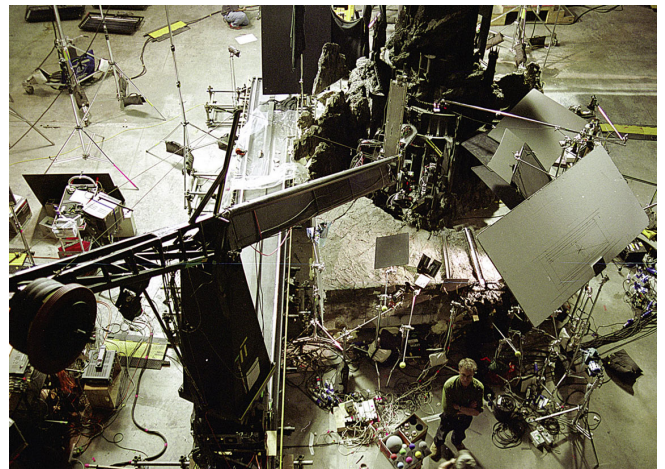
Assisted by the reference, John Feather, Sven Jensen, Bradford deCausin and Raitt sculpted broad expression poses, then built on those. "Gollum wasn't the kind of character where we could sculpt a pose, bend that and call it a performance," commented Raitt. "He needed to be able to cry, to have his whole face in complete compression, then be able to act from there. Regular boning, enveloping and muscle systems would not suffice because the animators needed to animate and read expressions in real time. So we sculpted big expressions — terror, compression, stretch — stress-tested those, analyzed control structures and sculpted muscle poses in combinations."

Raitt and his team sculpted all of Gollum's expressions in IZware's Mirai, a real-time gaming program Raitt had helped develop in San Francisco. The flexibility of the system was put to the test in January 2002, when Peter Jackson announced his intention of melding Gollum's physiognomy with Serkis'. "Andy let us draw lines all over his face," said Raitt. "We scanned him with our laser scanner as he performed our poses, then we built a digital version based on Peter's new brief, while Richard Taylor, Alan Lee, Randy Cook, Christian Rivers, Gino Acevedo, Jamie Beswarick and I redesigned Gollum in sketches and in clay."

As the clock ticked down, the physical redesign and digital modeling tasks were tackled simultaneously. "We knew we had to get the design locked off as fast as we could because animators had to animate it and it had to go through shading and lighting," Raitt said. "I'd grab the rough sculpt off Jamie's desk, run back to our building, scan it into my computer, place it inside a control cage cube, then start pulling it around. Jamie would sit at my desk, test to see how a brow shape might behave when we raised or lowered it, then run back and start sculpting again." In need of immediate feedback, Richard Taylor



The Tower of Barad'dûr, citadel of the Dark Lord Sauron – glimpsed under construction in The Fellowship of the Ring– is revealed in The Two Towers in an epic shot that rises from the plains of Mordor to the top of the structure in one continuous move. Weta Workshop fabricated Barad'dûr as a 25-foot-tall, detail-encrusted miniature.



Director of miniatures and visual effects photography Alex Funke filmed the tower, lighting and matting the miniature in sections through the complex camera move. Weta Digital layered the miniature photography into a matte-painted landscape and capped the tower with a fiery disc representing the Eye of Sauron.

brought the sculpture to Peter Jackson's editing suite and resolved issues of redesign on the spot. "Richard knew it was best to make changes right there; so when Peter commented that the ears were still too pointy, Richard grabbed a kitchen knife and cut right into the clay! When Andy came back and saw what we had built, he said, 'Oh my God, that looks like a cross between my dad and my son.' That was a tremendous compliment."

The Gollum facial model consisted of 675 sculpted expressions, with 9,000 sculpted muscle shapes. Individual sliders controlled sculpted shapes, giving animators the ability to cross-fade expressions in quadrants of the face, then apply individual muscle control. Animators could save, delete and mix preset slider settings. "Terror," for example, could be programmed, its settings saved for instant recall. Fran Walsh worked with Raitt to develop preset expressions, many of which Gollum reproduced directly on the screen.

Because Gollum had so much dialogue in the film, the animation team researched the possibility of doing procedural lip sync, but determined that it looked too robotic; and so, all of Gollum's lip-sync was key-frame-animated. Raitt created a library of mouth shapes corresponding to phonemes and gave animators the ability to mix them with preset facial poses. Animator input produced three golden rules. "One: Write out all your lip sync," Raitt related. "It really helps to do a dope sheet and write out what phonemes you want where. Two: Don't try to hit every phoneme. Let them mush over each other. The 'plosives' — the 'm's, the 'b's, the 'p's and the 'th's — hold those for an extra frame or two. Three: When you're done with everything, grab all of your key-frames and slide them two frames forward. Trust me. It works. You make the shape before the sound."

Throughout the redesign, Gollum's skeletal structure and musculature from the neck down remained intact. The creature setup team gave animators the choice of using forward kinematics, manually positioning each joint, or inverse kinematics, placing hands and feet and allowing the computer to interpolate dynamics. Again the basic brief was, as far as possible, to give the creature human anatomy, including approximately 700 muscles, a simulation of breathing lungs, and subtle dynamics suggesting twitching muscles and a beating heart. "Gollum had a full set of bones like a human skeleton," said creature lead Eric Saindon. "The skeleton drove a muscle system, with fold, compress and jiggle. We then had a skinning system, which worked with the muscles to create realistic sliding, stretching and flexing of muscle dynamics. We found that because Gollum could move much more freely than a normal human being — he's a little lizard-like and capable of bending in ways that most people can't bend — normal muscle action didn't look quite right. So we had to add a few more muscles and rework certain areas." Gollum's bony shoulder blades and hips proved to be the most problematic, requiring technical directors to massage muscle deformations and skin tolerances whenever animators pushed the model into extreme poses.



Inside his fortress of Orthanc, the wizard Saruman (Christopher Lee) communes with Sauron via a Palantír 'seeing stone.' Lee performed the scene with a white sphere representing the Palantír. Weta Digital used volumetric shaders and digital animation techniques to generate the Eye of Sauron seen inside the crystal. Sony Pictures Imageworks — which contributed approximately 100 visual effects shots to the film — composited the eye into the Palantír plates, tracking elements to a black 3D sphere rendered with highlights, reflections and animated clouds.



Hobbits Pippin (Billy Boyd) and Merry (Dominic Monaghan) escape their orc and Uruk-hai captors during a surprise attack by a band of rangers on the plains of Rohan. The scene required Weta to reestablish the hobbits' diminutive scale. Production shot a motion control take of the action without hobbits, then re-staged the scene on a greenscreen stage with the camera further away from Monaghan and Boyd, shrinking them in frame. Compositor Alex Lemke then layered the hobbits into the shot.



As Pippin scrambles up a tree in a forest where he and Merry have sought shelter, two luminous eyes open in the bark, revealing Treebeard – leader of the ents, an ancient race of sentient trees. Boyd performed the scene atop a 14-foot-tall mechanical ent constructed by Weta Workshop and filmed against bluescreen. Weta Digital replicated the ent puppet's richly textured surface to create a key-frame-animated face – replete with armor-plated bark, interactive moss, volumetric eyes and procedurally generated foliage – that was mapped to the practical creature's head.

To accommodate deformations of Gollum's skin, Matt Aitken and software development supervisor Richard Addison-Wood revised their approach to skin surface technology. "The first Gollum model was made up of NURBS surfaces," noted Addison-Wood, "modeled as a series of square patches in a grid arrangement. Gollum's hands and feet, for instance, required a lot of patches stuck together, with their fingers and toes sprouting out, and there were some minor issues of patches cracking at the seams when we used displacement maps. So we decided to change the geometry for Film Two to subdivision surfaces, which created a smooth, organic surface, subdividing all the details so there wouldn't be any seams."

Custom software translated the existing NURBS model into a subdivision control cage. From there, modelers made modifications to take advantage of the topological flexibility of subdivision surfaces. "Modeling with NURBS has its advantages when it comes to texture-mapping," explained Matt Aitken. "When you distort a patch, it drags the texture with it, and the relationship between the surface and the texture comes for free. We call it 'implicit u/v mapping,' where 'u' and 'v' are vectors in curved space. With subdivision surfaces, a modeler has to define the relationship between the texture and the 3D shape, which takes a bit of time. There are limitations to both ways of modeling."

Rather than attempt to hand-paint displacements to the detailed model, Aitken's team enlisted Weta Workshop's help in sculpting textures directly to CG. Digital artists took low-rez data of Gollum's 3D head and employed a technique similar to stereolithography to create a low-rez casting, complete with digital facets. Weta Workshop then cast the shape in clay and sculpted fine detail. When Weta Digital laser-scanned the clay, the high-rez displacement surface fit the proportions of the animation model. "Gollum's ears, the top of his head and all of the little scabby patches on his right



Despite decades of illustrations depicting the many creatures and environments of Middle-earth, surprisingly few artists had clearly depicted Treebeard and the ents. Weta Workshop designer Daniel Falconer initiated ent designs with a thumbnail sketch of Treebeard, partially inspired by a John Howe illustration. More refined concepts took form as three-dimensional maquettes, incorporating features of New Zealand's indigenous and exotic plant-life.

temple came from this extracted displacement process,” explained Aitken. “It was an interesting interweaving of physical and digital.”

The blend of physical and digital continued in the design of Gollum’s skin. Prior to the redesign, Gino Acevedo devised Gollum’s color scheme by airbrushing a urethane hard-cast from Weta Workshop’s maquette. The early version favored subtle olive greens with a pale underbelly, somewhat like a tree frog. For Jackson’s revised concept, Acevedo took a silicone casting from Jamie Beswarick’s slightly smaller-than-life-scale sculpt and applied an established airbrushing technique. “I’ve been painting silicone since the early nineties, on *Death Becomes Her*,” said Acevedo. “Back then, I realized how important it was to get the base color just right, making sure that it’s not too translucent; otherwise it ends up looking like a Madame Tussaud’s wax model. I then airbrush on acrylics, keeping colors very thin so the base shows through; then I do a lot of speckling to break up the skin surface. Acrylics don’t stick to silicone, so I mix in a silicone adhesive thinned down with methylene chloride, which is an aerosol propellant and very nasty stuff. That bites through the layers of paint, bonds to the surface and seals the paint. It’s a technique I still use to this day.”



Daniel Falconer sculpted a series of full-body and facial studies of Treebeard prior to the construction of a hobbit-scale animatronic puppet, built from the knees up to be used for closeup interaction with hobbit performers.

The silicone paint technique was similar to those Joe Letteri had explored in his quest to create translucent CG skin. “I became interested in what makes skin look like skin while I was writing shaders on *Jurassic Park*,” said Letteri. “There has been a lot of research in layered, translucent skin simulations, but the one I was most interested in for Gollum was in a paper Henrik Jensen presented at Siggraph 2001, called ‘Subsurface Scattering.’ This was a simulation that created skin translucency by scattering light not only through the pigment, but also through the blood. This, to me, was the first technique that really captured the way light diffuses in skin; and I thought it would be a great way to reinforce the flesh-and-blood reality of Gollum.”

Letteri enlisted Ken McGaugh, Kevin Smith and Sergei Nevshupov to develop Gollum’s skin shader.

“Many people have struggled to create translucency in CG skin by modeling all the layers,” noted McGaugh, “but once you start modeling dermis, capillaries, blood vessels and fatty tissues, it becomes very complicated, with terrible render times. While we were working on this problem, Joe Letteri saw a silicone model of Sean Bean that Richard Taylor’s team had created for Boromir’s funeral in *Fellowship*. He was stunned at how real it looked. Richard explained their silicone paint technique, how they use a homogenous underlayer, painting on thin layers of detail to create the illusion of depth with surface paint. This gave Joe the idea that we should model Gollum’s skin in the computer the way Richard’s artists paint their silicone models, as opposed to trying to re-create real skin. That made my life a whole lot easier, and the end result was very much like what you might see if they had built and painted a practical Gollum.”

An exchange began, with members of the shader team visiting Weta Workshop to glean information on how to achieve Gollum’s pallor. Through natural evolution, Acevedo exchanged his airbrush for a stylus for the first time in his career. “I crossed over to the *Dark Side*,” Acevedo quipped. “They set up a computer in my studio and we started doing tests. I painted slabs of silicone with all the veins and tiny moles. Sergei Nevshupov scanned those and used them as a basis to start his CG work. Eventually Sergei taught me how to airbrush in the computer using Maya Studio Paint, painting in 3D space, in real time. Everybody asked me how I liked the transition. I have to say it’s a whole new medium. I’ve got all my favorite colors, they never run out, and they never spill. I told the guys at Digital, if they could just put a couple of vents on the side of the monitor and blow toxic fumes in my face, it would be perfect!”



Master painter Alastair Maher administers cosmetic details to the Treebeard animatronic. Constructed over an aluminum armature and skinned with flexible urethane cast from a tree just outside Weta Workshop, the puppet could perform head articulation and body movements. Pneumatic hands were capable of gripping performers perched on concealed bicycle seats.

Acevedo also provided the basic color design for Gollum's pale blue eyes, which Steve Demers adapted into a deep, refractive shader for Fellowship. "The Film One eyes used multilayered veins, capillaries and irises," said Letteri. "The look was pretty great, but Gollum had so many scenes in Two Towers we streamlined those effects into a single pass, still creating highlight breakup and refraction in the irises. Pete also decided that he didn't want the eyes to glow this time; he wanted them old and dissipated."

For extreme closeups of Gollum, Nevshupov applied detailed skin textures by hand, including dirty makeup on Gollum's feet and knees and tiny veins in the ears. Other details were created as

displacement bumps on the surface and by the specular qualities of Gollum's clammy skin. Ken McGaugh wrote code to create wetness inside Gollum's lips, nostrils and eyelids. To clad Gollum in a ragged, droopy loincloth and control the creature's lank, greasy hair, Eric Saindon implemented Maya Cloth simulations. "It was a tricky hair solve," said Saindon. "The strands were quite long and thin and tended to get tangled on Gollum's fingers or caught in his mouth. He only had 25 hairs on his head, so when they were misbehaving you really noticed where every one went."

Gollum's first appearance in *The Two Towers* has the character waking the hobbits and wrestling Sam and Frodo for possession of the Ring. "For the fight scene," said Brian Van't Hul, "Peter would have Andy and the hobbit actors in the rehearsals and during 'block-throughs.' We'd shoot an animation reference pass, with Andy in his gimp suit, touching and interacting with the actors and the environment. Then we'd shoot a mime pass without Andy in the shot, the hobbits pretending they were looking at him." For actions that were nearly impossible to mime — such as the characters and Gollum grappling and rolling around on the ground — production also often shot a clean plate, without any of the actors, which could be used to paint Serkis out of the animation pass.

The filmmakers had hoped to use mime passes most often to avoid having to paint out Serkis from every shot; but, invariably, the best performance takes were those with Serkis present in the scene. "Having a physical presence in the shot," said Van't Hul, "with the actors looking at a real performer and Andy grabbing Elijah's arm and wrinkling his clothing, was much more convincing. Peter liked those plates so much he decided to make them the hero plates, and he asked us to paint Andy out and put Gollum in — which at first seemed very daunting. We had shot a lot of clean passes, but not all of them were motion control. So it came down to a huge, heroic effort from our paint department to paint Andy out and patch together 'Invisible Man' plates with just Sam and Frodo in there, with all the physics of dirt being kicked about and the actors being pushed around. It then became a matter of going back in and putting Gollum over the top."

Integrating the CG Gollum with the live-action plates was a compositing challenge, particularly in the fight scene, which had the character physically interacting with the live actors. "We spent a lot



In addition to the CG facial apparatus incorporated into the full-body practical Treebeard, digital model supervisor Matt Aitken oversaw construction of eight all-CG ent species for the 'entmoot' gathering at Derndingle. Weta Workshop and conceptual artist Alan Lee provided drawings and maquettes of ash, beech, birch, fir, linden, oak, rowan and willow to guide Aitken's team, which modeled each genus using subdivision surfaces and varieties of procedurally created foliage.

of time on the interaction between Gollum's feet and hands with the ground and his interaction with other characters," noted compositing supervisor John Nugent, "and we shot a lot of physical elements like dust hits and gravel movements. We then made him fit the long and hard way, by tedious frame-by-frame manipulation of the 2D plate."

"Probably the most extreme example in that scene," added sequence lead Greg Butler, "was a shot in which Gollum's arms and legs pin Sam down and he bites him in the neck. Luckily, we did not see the closeup of the actual bite; but each limb wrapping around Sam was the result of painstaking paint and composite work. The paint department very much proved its worth to the whole film in that sequence."

Compositor G.G. Heitmann Demers was the predominant Gollum point-person among Nugent's team of 45 compositors and 25 rotoscope and paint artists who cloned, warped and painted whatever textures were available. "For shots where we didn't have a motion control clean plate," said Butler, "we'd have to hunt around for any random take that happened to show the piece of the set we needed, grab that and try to make it fit. When we had a few frames where Andy obscured Sam's face, we chose a frame from another plate where Sam didn't have too much of an expression, copied his face and tracked that to his body. We had a lot of quick cheats like that, grabbing pieces for the background — without them, we had nothing."

As the fight plays out, the hobbits overpower Gollum, who collapses, sobbing. The dialogue and interplay that follow — Gollum attempting to ingratiate himself to Frodo, and Frodo attempting to discern the creature's true motivation — were subject to scrutiny as the film and Gollum's character evolved. "Gollum was really the villain in the books," Peter Jackson stated. "While we were editing, we discovered he had a very sad, pathetic side. Sméagol was really quite childlike, and his Gollum alter ego led him into bad ways. We wanted to make that much more poignant and emotional, so we decided to develop his psychology and shoot new sequences during postproduction."

In early 2002, Elijah Wood, Sean Astin and Andy Serkis returned for additional shooting, Serkis in a pinker version of the gimp suit that revealed his facial features. All pickup scenes were filmed as studio elements, many with bluescreen or greenscreen backgrounds, and incorporated three crucial week-long sessions of Gollum motion capture.

"Motion capture was always a caveat of Peter's with Gollum," said Randy Cook. "It's a very interesting tool; and for some types of animation, it's great. For my tastes, the more you deviate from realistic action with motion capture, the more difficult it becomes to manage. For instance, if you had a great dancer like Gene Kelly, and you were animating long shots of him dancing, it would just make sense to motion capture Gene Kelly, because who could dance better than Gene Kelly? That was the philosophy behind Peter's use of Andy. He loved not just Andy's voice, but the physicality of what Andy could do; and, as a result, we relied upon Andy to contribute not just movement but a physical performance. 'Mocap' is only as good as the 'mo' you 'cap' — and fortunately Andy provided some terrific 'mo!'"

Motion capture supervisor Remington Scott joined the Weta team, in January 2002, specifically to tackle the challenge of recording and incorporating Serkis' motion capture into existing plates. In very little time, and with a minimal crew, Scott and his team redesigned Giant Studio's existing optical mocap system, expanding the 16-by-13-foot, 16-camera grid to a 20-by-30-foot, 24-camera

space. The larger stage allowed Jackson to shoot longer and wider master shots, rather than breaking takes into individual cuts, and it gave Serkis the opportunity to create an uninterrupted performance. Serkis wore a custom mocap suit, with 50 body markers manufactured by senior stagehand Frank Cowlrick. The tiny rubber stems, which stood away from the actor's body to help prevent occlusion, reflected intense white halogen light from their Scotchlite tips, providing high fidelity detail down to toes and fingers. Serkis also wore Scotchlite dots on his face, applied by painting through a vacuform mask, which helped the animators track in facial animation.

The 3D camera department provided motion capture with technical breakdown of live-action shots, including 3D terrain geometry and single-frame lineups with a rough Gollum model. Scott's crew positioned wooden props to approximate gradients and obstructions in the plate, then aligned Serkis on the props. "One of the most difficult aspects of the motion capture was retargeting Andy in real time to Gollum's proportions," said Scott. "We wanted Peter to be able to see that wherever Andy's arm bent, Gollum's arm would continue, and wherever Andy looked, Gollum's eyes would follow, although Gollum's neck was much longer and thinner. That took a lot of tweaking of our offset-mapping program — Character Mapper — but we had a very limited amount of time with Peter; so we gave him the best we could, then had to move on. It was a real pressure cooker!"



Gollum leads Frodo and Sam from Eryn Muil towards Mordor, crossing the apparently limitless Dead Marshes. Jackson filmed ground-level views of the marshes entirely on soundstages, utilizing two versions of a flooded set – one with practical mist and marsh-gas fire effects, and one without. Weta matte painting and digital environment departments provided sky and landscape extensions. Compositors added atmospheric effects to match the misted set, blending practical and animated mist around Gollum and the hobbits with minimal volumetric particle animation.



As Frodo tramps through the marshes, the faces of spectral corpses – remnants of an ancient battle – peer up at him from the water and lure him into its murky depths. Weta Workshop created silicone prosthetic masks of

emaciated zombie characters for the sequence. Visual effects cinematographer Brian Van't Hul photographed masked performers in slow motion, dry-for-wet. Sony Imageworks then composited the elements, adding floating debris, caustic light effects, bubbles and layers of transparency that rippled and distorted the creatures to give them an ethereal look.

Motion capture technicians James Van Der Reyden and Mark Schaefer recorded 686 takes of 315 Gollum actions, accumulating over 1.8 million frames — a total of eight hours — of motion capture data at 60 frames per second. Three digital video cameras also recorded takes for animation reference while Serkis performed to either original production audio, Gollum's isolated lines or a 'bloop' track with electronic tones representing action cues. Video assist operator Richard Shaw superimposed performances against the production footage for Jackson's or Fran Walsh's review. Randy Cook then directed a team of ten motion editors who processed the data in Kaydara's Filmbox and Giant Studios' Nuance, tweaking and correcting alignments to the plate. "The only difficulties with the motion capture were in differences between Andy's and Gollum's proportions," Cook commented. "Andy's muscularity caused his joints to stop in compression much earlier than Gollum's, so we did not automatically get the flexion and compression in Gollum's limbs that we would in Andy's. Usually we would interpolate Gollum from Andy's motion capture; but there were often actions that Andy just could not portray as interestingly as Gollum. That was where key-frame animation took over." Gollum's pleading scene was entirely motion captured, while the remainder of the Eryn Muil sequence was half motion capture and half key-frame animation.



Edoras – hilltop refuge of King Théoden, steward of the refugee Gondorians – was realized via a combination of practical and digital set pieces. At a remote New Zealand location, production designer Grant Major erected the top most portions of the set, built to withstand the area's high winds. Weta Digital provided the lower hillside structures – spreading out and down to the perimeter walls – and added drifting smoke and digital crowd simulation characters, affixed to the terrain with custom matchmove and tracking utilities.

Saruman receives word from Sauron that the time has come to mobilize their twin forces. Christopher Lee performed the scene playing to a white sphere that represented the Palant'r, Saruman's 'seeing stone' hotline to his Dark Lord. Sony Imageworks tracked a black 3D sphere to the Palant'r plates and rendered the object with a highlight surface pass, reflections and layers of animated clouds that faded into an image of Sauron's fiery, all-seeing eye. Weta provided the Eye of Sauron element, which was retooled from the existing design. "It was a fairly labor-intensive process to produce particle-based shots of the eye in Fellowship," said Gray Horsfield, "but it really didn't stand up to the kind of scrutiny we needed in the next two films. I rebuilt the Eye of Sauron using volumetric shaders instead of particles, which allowed us to import the object, render it — then our shot was done. We had a little flexibility to enhance the effect because, previously, the eye was only seen in visions; it was not an entity in space. In Films *Two and Three*, it takes physical form."

As Uruk-hai begin to stream out of Isengard, legions of orcs are seen in Mordor, leaving Barad'dûr. Previously glimpsed in Fellowship covered in scaffolding and under construction, Barad'dûr is revealed in all its glory in *The Two Towers*, soaring above a lava gorge and capped with the Eye of Sauron, a gigantic disc of fire generated between the tower's topmost spires. The miniature fortress, constructed at 1/166-scale — equivalent to tiny N-gauge, or 9-millimeter, model railway scale — stood 25 feet tall.

To design the tower, senior miniatures technician Mary Machlachlan sculpted a six-foot-tall clay maquette based on a rendering by John Howe. "Barad'dûr was like a city on a city, built like a termite mound," Machlachlan observed. "We imagined hundreds of thousands of people had burrowed into it and built little bits at different times, piling one section on top of another. The lower areas had very linear architecture; but further up, where the orcs took over, it had this Gaudiesque, organic, dripping look."

Machlachlan and a 12-person crew sculpted the miniature over a period of 12 weeks, carving the base out of polystyrene, and scaling up architectural detail freehand. Workshop technicians molded the sculpture in sections and cast surface textures in thin shells of hardcoat, a lightweight semi-flexible urethane. John Baster oversaw miniature substructure assembly, creating a steel frame in two sections, the upper portion capable of being hoisted by a concealed hook, then lowered onto its base. Machlachlan's crew affixed hardcoat castings to the frame, then applied acid-etched spikes, spires, window gratings and railings, with a balcony at Sauron's upper rooms. The miniatures team also built a larger-scale section of the entry bridge for closeups.

Featured in a tour-de-force, 270-degree, rising, spiraling, detail-hugging camera move, the 1/166-scale miniature posed a lighting challenge. "It was an amazing shot," remarked Funke, "and an incredible nightmare to shoot. There were two issues. We had to stretch our camera boom to its limit, and it was mechanically very hard to run our big Praxis snorkel lens around the model. Matting was also difficult because we needed to shoot a matte that wrapped all the way around, without the boom and camera equipment getting in the way. Motion control operator Henk Prins worked out the move, and chief lighting technician Rob Kerr devised a lighting scheme that incorporated a series of mattes. We matted around the tower in sections, re-lighting as we went around." At the tower's uppermost level, Funke's team installed a Kino Flo fluorescent tube behind a cardboard cutout of the Eye of Sauron, then shot passes with and without flicker to help compositors integrate the animated effect.



Weta Workshop makeup artists Deb Watson and Marjory Hamlin apply a latex stipple makeup to Théoden performer Bernard Hill. The old-age makeup, complete with rheumy contact lenses and a bald cap beneath a sparse wig, simulated the king's diminished state wrought by the evil influence of Mordor. Hamlin and Watson applied two additional makeups to Hill for a scene in which Gandalf magically restores the king's health and vigor. Artists at Weta Digital morphed between the three stages of makeup to create the illusion of Théoden's rejuvenation.

To blend the miniature Barad'dûr into the Mordor landscape, matte painting lead Max Dennison adapted an existing matte painting created by Yanick Dusseault for Fellowship, and worked with environments technical director Hiroaki Muramoto to expand the plate to accommodate the 270-degree rotation. "Rather than do a complete repaint," explained Dennison, "we took Yanick's painted elements and massaged them together to give the scene a slightly different feel. We started at the end frame, which was a painting of Mount Doom, then we handed that back to the compositor who was working in Inferno 3D space, projecting the painting onto a sphere. He moved that back to the next camera position with a little bit of the previous painting overlapping, then gave that back to me. I continued the painting until we covered the move all the way around."

The action shifts to Merry and Pippin being carried roughly across the plains of Rohan by their Uruk-hai and orc abductors, tracked by Aragorn, Gimli and Legolas. In the company of the orcs, the hobbits experience the creatures' bickering at close range. "We always imagined the orcs as a troop of baboons," Weta Workshop designer Daniel Falconer related. "They are all grunts in one big army, rallied under Sauron. In *The Two Towers*, we see interaction between the Isengard orcs under Saruman and the Mordor orcs under Sauron. Uglök is one of Saruman's Uruk-hai, while Grishnákh and Snaga are from Mordor."

Weta Workshop sculpted 100 generic orc heads, then mass-produced and detailed them with prosthetics to create a repertoire of characters. Closeup orc performers wore foam latex facial prosthetics and latex body suits, requiring six to seven hours' application time, with teeth and scleral contact lenses also designed in-house. Australian lens specialist Bill Perriman provided cost-effective stock lenses for background characters, enabling Peter Jackson's camera to penetrate the scenes as deeply as the director wished, without compromising the believability of the characters.

A surprise attack by a patrol of Rohan rangers decimates the orc troops and sends the hobbits scurrying for safety. The scene required some of the few scale tricks used in *The Two Towers*. "We had already established the relative sizes of our characters in Fellowship," stated Jim Rygiel, "so we didn't really need to repeat ourselves too much. We had a couple of little scale tricks in the ranger attack. We sometimes placed Merry's and Pippin's shorter doubles in with taller Uruk-hai and Rohan performers. There were horses charging back and forth; so, for safety reasons, we also used repeat takes and composites."

For a shot of Merry and Pippin ducking underneath the legs of an enormous galloping horse, stunt riders plotted horse action crossing frame and leaping over fallen Uruks. Brian Van't Hul recorded a motion control take, scaled the move to hobbit size, rephotographing the action on a greenscreen stage with the camera 1.38-times further away from the hobbit performers, shrinking them in



After their trek across the Dead Marshes, Gollum, Frodo and Sam hunker down to view an army of Easterlings – men under Sauron's influence – marching through the Black Gates of Mordor. Peter Jackson filmed Elijah Wood, Sean Astin and Andy Serkis on a partial set backed by bluescreen. Weta Digital filled out the frame with a giant digital cyclorama of craggy mountain peaks, composited with a miniature of the imposing iron barricade and a digitally animated troop of marchers.

frame. Dominic Monaghan and Billy Boyd ran and ducked at the appropriate time and leapt over apple boxes simulating fallen Uruk-hai. Composer Alex Lemke layered the actors into the scene, matting them behind foreground action and adding dust and shadow passes to lock them into the plate.

Merry and Pippin flee the Rohan riders' ambush of the orcs, dart into a forest and run for cover in the trees. Grishnákh, the Mordor orc with a taste for hobbit flesh, takes after them, loping through the underbrush — his savage demeanor enhanced by subtle digital enlargement of his eyes. Forest scenes were filmed on interior sets constructed by production designer Grant Major and his art department, with a matte painting by Roger Kupelian enhancing a wide exterior view of the foreboding forest rim.



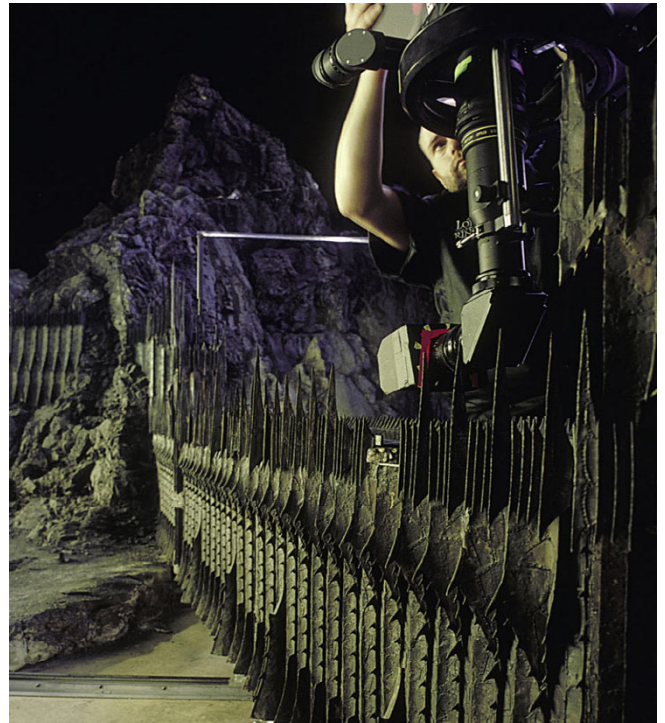
*Propelling the Black Gates, a pair of mountain trolls harnessed to a wooden beam are whipped into service by orcs. Weta Digital created the trolls by modifying an existing CG model of the cave troll seen in *The Fellowship of the Ring*.*

To hide from Grishnákh, Pippin scrambles up a tree and grabs a protuberance in the bark. A pair of luminous eyes open, revealing Treebeard — leader of the ents, the oldest living race of creature in Middle-earth. “The idea of a walking tree could have been exceptionally hokey,” remarked Daniel Falconer. “Pete told us he didn’t have a strong idea of how he wanted Treebeard to look so much as he had a strong idea of how he didn’t want him to look — he didn’t want ‘the carrot with a face look.’ I always had a very strong impression from reading the books that Treebeard would look like a ‘mannish’ tree, as opposed to a ‘tree-ish’ man.”

In an early design meeting, Falconer roughed out a thumbnail sketch, partially inspired by a John Howe drawing of Tolkien’s Sir Gawain and the Green Knight. The drawing caught Peter Jackson’s eye and, although the Workshop staff produced further iterations, Jackson kept returning to Falconer’s first intuitive design. Discussion then turned to the most effective method of realizing the ent. “We felt strongly that if the hobbits had to climb around on Treebeard’s branches we’d really need some form of animatronic,” asserted Richard Taylor. “However, we also knew there would be no need to get into elaborate facial animation through animatronics. With the incredible skill and abilities that they had, Digital was going to be able to animate Treebeard’s face at a vastly higher level than we could by pushing huge chunks of foam rubber around with large servos.”

Workshop artists and engineers constructed an animatronic Treebeard over a period of 12 weeks. Falconer initiated the process by sculpting a series of 1/8-scale maquettes and facial studies. Dominic Taylor then built a 14-foot-tall aluminum armature for an articulated, from-the-knees-up puppet, made to hobbit scale. Taylor equipped the Treebeard armature with footholds for the actors to climb, and two rod-puppeteered arms with pneumatic hands capable of gripping the performers, perched on concealed bicycle seats. The armature provided head articulation, arm-swing and body-sway, and rose and fell on pneumatic pistons atop a wheeled trolley to simulate Treebeard’s loping gait.

Foam technicians sprayed the armature with urethane. Then Shaun Bolton and a team of artists carved the foam to the proportions of Falconer’s maquette. Falconer meanwhile sculpted Treebeard’s face separately in clay and devised the cosmetic look for the puppet. “We took a silicone molding of a tree just outside our workshop,” related Richard Taylor. “It was a species native to New Zealand, a pohutukawa. We painted molten clay into the pohutukawa mold; and out of that we pulled thin skins of Plasticine, which Daniel applied to the surface of his sculpture. Back in the



Camera assistant Stephen Allanson prepares a high-angle view of the forbidding entrance to Mordor. Weta Workshop built the miniature structure from lead sheet, aged to look like rusty iron. The gates were rigged with motion control movers on linear rails and push-rods, enabling them to move incrementally, emphasizing their apparent weight and scale.

workshop, Shaun Bolton and his team took similar molds and sprayed them with a flexible urethane, which was similar to the material used on the headrests and steering wheels of cars. It was dense and spongy and very flexible, and created wonderful skins. We laminated those with great care onto the surface of Treebeard, following the structure of the bark.”

Art director John Harding supervised Treebeard’s skin design, which, after painting, included a canopy of silk leaves, local shrubbery, foam fungi, flocking, dried moss, and spider-webs achieved by blowing dust through a jet of spray adhesive. During a flora-gathering expedition, Harding also procured a kauri snail — a giant gastropod, native to New Zealand — whose three-inch-diameter shell scaled perfectly to hobbit size when nestled into Treebeard’s beard.

Jackson photographed the Treebeard puppet and hobbit performers against bluescreen, using motion control. The ent’s facial features, however, did not come to life until well over a year later. “Right after we finished Fellowship, we started discussing how much of Treebeard we would re-create digitally,” recalled Jim Rygiel. “At one point, we talked about doing a Babe-style morph trick, animating just the eyes and nose and mouth, and tracking that area to the puppet. It came down to time — how long would it take to rotoscope around Merry and Pippin and every little piece of foliage surrounding them? How long would it take to render Treebeard’s beard? Richard’s puppet was really beautiful; but the beard didn’t animate, so we knew we’d have to re-create that, too. In the end, we decided we’d keep the majority of the puppet, but replace the whole head since that was the area the hobbits would be talking to.”



Saruman addresses his Uruk-hai army from the balcony of the Orthanc tower. Jackson covered the scene in a roving Steadicam shot, beginning inside the tower set, then following Saruman onto a balcony set piece, backed by bluescreen. Weta Digital tracked the shot to a 3D environment fashioned from matte-painted elements and film plates of Weta Workshop’s Isengard miniature, then populated the terrain with thousands upon thousands of CG Uruk-hai, created via ‘Massive,’ an advanced crowd simulation program – developed in-house – that produced characters capable of autonomous behavior.

For wide shots of Treebeard striding through the forest on his enormously long legs, Weta Digital’s 3D model team created a full-body digital model that was based on the Workshop design. “There were two aspects to modeling Treebeard,” said Matt Aitken. “Occasionally, we used subdivision surfaces, because they were sometimes faster to work with; but in many shots we utilized a 2,600-patch NURBS model that we developed during Fellowship. Using Richard Addison-Wood’s code, we could flip back and forth between either type of model.”

While Treebeard's form was modeled through the hero creature pipeline, it was not practical to model the character's foliage — all his branches and thousands of leaves — by hand. The task of modeling ent foliage became a pet project for Aitken, who drew initially on his master's thesis on L-systems — a procedural system used to model organic branching structures. "L-systems are a great concept to explore in academic work," Aitken asserted, "but they don't lend themselves to production. They require a hell of a lot of processing to create random variation; they involve very long alphanumeric strings of code; and they're very memory intensive. After a lot of tests, we decided not to use L-systems for modeling our ents. Instead, I developed a more compact and manageable piece of code called 'Grove' — which doesn't stand for anything. I just liked the sound of it."

First used in *Fellowship* to model forests around Isengard, Grove came into its own in *The Two Towers*, used for modeling vast armies of ents and for closeup detail in Treebeard's animated beard. For the CG ent model, digital artists first laser-scanned the bare bark surface of the large-scale Treebeard puppet face, providing the foundation and a rich texture reference for Guy Williams and a five-person shader team. "The great thing about Richard's puppet was that it was made up of so many different kinds of surfaces," said Williams. "We did the same thing with our textures. We photographed the puppet; then our two main texture artists, Sergei Nevshupov and Hillary Yeo Tze Ann, went up to the Wellington Botanical Gardens and shot photographs of every tree, at every distance, to create a detailed reference library. We used three diffuse models and two specular passes to make the bark. Sergei painted all the closeup textures to the face, then Hillary extrapolated that down the rest of the body."

To generate Treebeard's digital beard, Jeff Hameluck took a RenderMan hair primitive of a smooth, flat ribbon shape, then wrote a shader to convert that ribbon into a tube and 'scraggle' it into random branch-like shapes. Jane O'Callaghan used Hameluck's code to model Treebeard's beard. "We set up Grove as a parametric modeler plug-in for Maya," recalled Matt Aitken. "Modeling and animation all took place in Maya; then we had a second piece of code, a DSO — dynamic shared object — in RenderMan. During rendering, when RenderMan hit a part of the model that needed Grove, the DSO kicked in and regenerated the structure on the fly. That way, we avoided having to pass huge amounts of data through our production pipeline."

Hameluck also used shorter RenderMan hairs to simulate patches of CG moss. For longer, flowing tendrils, he created trailing tubular lengths, which grew 'rungs' from either side. O'Callaghan used Grove to dress drooping vines throughout the beard and, by varying transparencies and



Preparing to shoot photographic tiles of Isengard, modelmaker Bruce McNaught tends to Orthanc tower, a moveable set piece that could be positioned as needed within the miniature terrain. While Weta Workshop created all the major miniature elements for the picture, and continued to supply designs throughout postproduction, the miniature photography unit also established a construction crew to assist with on-set model dressing, fabricate detailed props and foreground miniatures, and occasionally fashion sets from existing elements.

backlighting, the beard took on a dense and multilayered organic appearance. Jamie Pilgrim programmed the beard to sway with Maya soft body dynamics, driven by Treebeard's character animation. "We also used soft body dynamics to rustle all his leaves in the wind," related creature setup lead Dana Peters, "even when he was stationary, trying to get a balance between creating enough motion and not distracting from the focus of the shot."

The legs of the full-body Treebeard puppet, which comprised two-thirds of the character's form, had been constructed of nonflexible material. To imbue the digital Treebeard with an appropriately wooden feel in its body animation, digital artist Sven Jensen devised a motion tool giving animators the ability to add layers of micro-movements to animation curves. "The movement of computer generated characters sometimes can be too precise," said Randy Cook. "We wanted Treebeard to be stately; but we decided that since he was mostly made of tree-like stuff, his movements should be quite staccato, almost like stop-motion with a little blur. We came up with a very sophisticated 'jitter' program; so, rather than moving through nice, smooth 'spliney' curves, we could dial in hard-edged linear bumps and jerks." Although the eccentricity of Treebeard's movement was important, it was subordinate to the drama of the character. "Over a dozen animators, led by Steven Hornby, worked together to create a charismatic performance that was both comical and touching. Treebeard was not only an impressive technical achievement, he became a very endearing member of the ensemble."

Jensen sculpted a full set of muscles for Treebeard's facial animation, which — like the animation of the body — had to allow for expressive features, but still retain some surface rigidity. "I kept the eyebrows rigid," Jensen explained, "but I made the lips extremely articulate so the animation would translate as a secondary effect through the beard." Jensen created 26 phonemes and 70 facial controls, including a 'sticky' eyelid control, so as the eyes looked right and left, the lids would distort across the corneal bulge and follow with a slight delay. Gino Acevedo had designed the ent's eyes to resemble amber crystals with deep flecks of green, as described by Tolkien. Guy Williams' team translated the design into 3D animated spheres containing layers of refraction maps in translucent planes.

Treebeard (voiced by John Rhys-Davies) comes to life and ends the hobbits' plight by raising a rooty foot and stomping Grishnákh into the ground — the CG foot composited over the live performer. Scooping up the hobbits, Treebeard carries them on his shoulders as he strides through Fangorn forest. The varieties of landscape and expanses of terrain traversed by Treebeard made it impossible to shoot the backgrounds on stage interiors or live locations. "Treebeard walks for about two days," said John Harding. "He climbs mountains, comes out onto a big rocky ridge overlooking Isengard, and walks out of the edge of the forest, which has been sliced down by the orcs. If we had attempted to film those scenes in the glorious forests of New Zealand, we would have been there



With Sauron and Saruman threatening war, Gandalf urges Aragorn and Théoden to prepare for the conflict by abandoning Edoras and seeking refuge in the fortified ravine of Helm's Deep. Aragorn leads a string of refugees across the plains of Rohan. Weta Digital motion-captured varieties of refugee performers, then used the data to digitally generate crowd simulations in Massive. Animated refugees were tracked to aerial plates and filled out live-action closeups shot on location.

for five months; and we would have destroyed the place, laying endless camera tracks for traveling shots and angles overhead.”

Weta modelmaker Dan King and his team instead built a miniature Fangorn, which filled a stage at Stone Street Studios with a 33-by-65-foot expanse of 1/6-scale trees, photographed using motion control data scaled to the bluescreen puppet shoot. The 150 miniature trees were all created from local flora. The model crew trimmed and fitted boughs of gorse — a hardy, twisted bush — into large ‘s’-bends spreading out into six-foot canopies, then sprayed urethane into the gaps, shaved away excess and laminated the trunks with real bark.

To simulate moss, modelmakers created large quantities of flocking by sifting pine sawdust with green and brown dye in a concrete mixer, then applied colors in layers, blowing the material onto painted glue. Fine branches and upper vegetation were created from mingi mingi, a dense arbor layer snipped in ten-foot sheets from New Zealand forest floors. Artists teased apart individual branches and frequently used entire sheets of ‘mingi mat’ to fill gaps in the forest canopy. On set, Harding and his team planted trees in potting mix on steel mesh ‘trampolines,’ suspended on wheeled tables three feet above the studio floor, which enabled artists to crawl underneath and rotate trees to camera. Dressed with mulch, grass and piles of rotting vegetation, the forest became a living entity, requiring daily watering and pruning. To fill out the far distance, the art department hung scenic backdrops around the perimeter of the stage.

Despite the moody look established by director of photography Andrew Lesnie and second unit cameraman Richard Bluck, the miniature forest required vast quantities of light — 400 tungsten Spacelites suspended above a white diffusion silk — to maintain depth of field. Each 250-kilowatt lamp array radiated considerable heat and attracted a few unwelcome guests. “The lights were so hot,” recalled Brian Van’t Hul, “we’d turn them on to shoot, sit back for the ten minutes or so it took to complete a pass, then turn them off again. What we didn’t notice was that when we turned the lights on, all these little spiders started coming out of the canopies. When we turned the lights off, the canopy cooled down and they disappeared back up into the trees. We were shooting at slower speeds for motion control, so the next day, in dailies, we had all these little yo-yos bouncing into shot, and we couldn’t figure out what they were.” A quick fumigation solved the spider infestation, but another visitor soon appeared on set. “We kept seeing shadows moving about in the back of shots. It turned out one of the studio cats had crawled up into the set to take a nap. When we woke him up, we had this giant-size mountain lion running through our forest!”

Bluck and Van’t Hul covered scenes with the camera on a boom arm, matching angles dictated by previz or data from the bluescreen plates. After completing takes, operators would swing the camera around and shoot coverage of the setup looking left and right from hobbit level, then from Treebeard’s elevated point of view, providing Jackson and his compositors with a library of backgrounds that could be married with bluescreen elements. The camera team kept motion control passes to a minimum, occasionally shooting foreground layers to matte vegetation over characters during composite assembly. Physical effects introduced atmospheric mist to the set to create haze and depth.

Treebeard takes an interest in the hobbits’ tales and carries them to Derndingle, a clearing in the trees, where representatives from each of the ent species — all distinctive in appearance — gather

around a ring of standing stones to discuss their fate. John Harding and his team dressed the clearing into the miniature Fangorn set by laying rolls of needle fescue — a particularly fine-blade grass — and created sundial-blade-shaped rocks from castings of real stones, painted in ochre hues.

Frodo and Sam, meanwhile, are forced to put their faith in Gollum as a guide, leaving Emyr Muil to pick their way across the apparently limitless Dead Marshes. For a wide shot showing digital doubles traversing the treacherous terrain, Jackson shot a helicopter view of a marshland on the south island of New Zealand, then Weta Digital environment technical director Imery Watson and matte painter Mathieu Raynault extended the landscape. “The scene was so large,” said Max Dennison, “we worked out that we needed a 200-degree painting at 16K resolution. Normal resolution for a film frame is 2,000 pixels across, and most of our matte paintings were between 4K and 12K; so 16K was huge. After a while, we rationalized it down to a single 4K painting, repeated the image and created elements to add variation.” Dennison’s team generated particle animation of foreground drifting mist, added painted mist for the background where parallax was less apparent, split out the existing horizon with a jagged mountain range, and replaced the sky. Watson projected textures onto 3D terrain geometry and animated the shot to fly over the characters, tilting up to reveal the marshes in perspective.

Ground-level views of the marshes were filmed entirely on soundstages, where the physical effects crew pumped mist into a flooded set. Jackson continued the scene with pickups on a larger set, without practical mist. “Production used practical mist for scenes on the smaller set because that was easier to control,” explained John Nugent. “For the wider set, they felt more comfortable adding mist after the fact to make it easier to integrate the 3D Gollum. We actually found that it wasn’t too difficult to add Gollum into the practical mist, but the dry set gave us more control.” Overall, mist and atmosphere were the compositors’ friends. “They were great tools to help hide any problem areas in composites, and they were also a great device to help sync objects into space and to create convincing depth. The mist on the Dead Marshes acted as a great backdrop for enhancing the drama of the nighttime scenes; but it also worked as a great mask to disguise the fact that we were on an interior soundstage set.” Compositors created illusions of depth by blending and matting combinations of practical and animated mist with minimal volumetric particle animation. Andrew Lesnie lit the unmisted set with a vivid ochre horizon to give compositors maximum latitude balancing colors in the plate and enabling The PostHouse to massage the scene to Jackson’s specifications in the digital grade.

As Frodo proceeds through the marshes, he notices faces in the water, remnants of fallen soldiers from a battle fought long ago. Frodo finds himself drawn hypnotically to a pool and falls in, plunging into a murky underwater realm — created through a blend of physical, digital and makeup effects. “Jason Docherty created weighted, silicone dummies of emaciated dead elven and Gondorian soldiers,” recalled Richard Taylor. “We sunk them underwater in a big marshy pond that the art department had built out in the back of the studio. We then dressed performers in ragged versions of those suits of armor, wearing very distorted silicone prosthetic masks in screaming, horrific, zombified poses, painted quite extreme purples and lilacs. We then suspended our actors from wires, looking down into the camera, and Brian Van’t Hul photographed them in slow motion with fans blowing at them through this beautiful set of hanging weed. Peter is a huge fan of dry-for-wet, because it gives him the ability to direct his actors.”

Van’t Hul supplied plates and technical breakdowns of the scene to Jim Berney, visual effects supervisor at Sony Pictures Imageworks, during the latter part of postproduction. Imageworks generated all the effects under the surface of the marshes, first seen as plumes of bubbles cascade around Frodo — created using a proprietary particle animation system, accompanied by crowd-based rendering techniques developed for *Harry Potter and the Sorcerer’s Stone*.

Imageworks’ original brief for the sequence was to simply warp the characters and add a green glow. “Of course, that just looked like we had warped them a little bit and added a green glow,” noted Berney. “We ended up creating fourteen digitally generated passes, including a background water element, surface bubbles, bubbles coming from Frodo’s mouth, bubbles rising up from the decay, floating debris, organic particles and God-rays. We then modeled caustic lighting on Frodo and the creatures, and treated the corpses to make them look ethereal.” Guided by conceptual art, Imageworks CG supervisor Peter Travers and compositing supervisor Jake Morrison performed rough rotomation of corpse performers and distorted the



Richard Taylor attends to horn-like protuberances projecting from a matted pelt covering the back of an orc, member of a cavalry division dispatched by Saruman to attack the refugees en route to Helm’s Deep.



Weta Workshop designed the cavalymen and their costumes to reflect the close symbiotic relationship between the orc riders and their ferocious steeds, called wargs. For closeups, actors in orc prosthetics rode a teeter-totter device on location, comprised of a section of warg ribcage on springs overlaid with a pelt and saddle.

figures with 3D ‘noise,’ warping the image with random ripples, generated to higher frequency in one creature’s hand as it reached toward camera. “We created a fresnel lens effect in the transparency, so as the creature waved around, it became a little more opaque at the edges. Then we filled it with ‘tendrilly’ layers of CG smoke and fog.”

The nine-shot sequence concludes as Gollum’s bony hand thrusts into frame, plucking Frodo from the water. Imageworks composited the element — a digitally animated limb supplied by Weta — replacing an actor’s arm in a bluescreen glove, which seized Elijah Wood on set.

Yet another nightmarish apparition, signaled by a screech from the sky, appears to the travelers as they cross the marshes. Terrified, Gollum urges the hobbits to hide, informing them that Sauron’s black riders, the Nazgûl, have returned to hunt them now as ‘wraiths with wings.’ Seen against the sky, a Nazgûl mounted on his steed fills frame; then the camera pulls back rapidly and a black shape wipes frame, revealing the rider seated on a giant, bat-winged creature — a Fell Beast. Peter Jackson photographed the Nazgûl against greenscreen and performed a tracking move back. Mary Victoria then animated the beast and rider to match the greenscreen element. Sequence lead Seth Lippman oversaw the handoff to a digital double astride a CG beast, revealed as the wing wiped frame. Modeled from a John Howe design and a Weta Workshop maquette, art-directed by Gino Acevedo, the Fell Beast was animated to resemble a giant, carrion bird with a wingspan approximating that of a 747 jet. Dana Peters set up wing dynamics to flex and billow like a giant bat-wing membrane. Lippman’s team rendered the creature with purplish-black, opalescent scales.

Aragorn, Legolas and Gimli, meanwhile, follow the trail of destruction left by the Rohan rangers outside Fangorn and venture into the forest in search of Merry and Pippin. They are startled by blinding light and draw their weapons only to see their fallen comrade, Gandalf, apparently back from the dead. Andrew Lesnie devised a practical lighting effect behind Ian McKellen for Gandalf’s reappearance,



Sharku, captain of the warg riders, was named after the Orcish word for ‘old man.’ Weta Workshop extrapolated on the name and fashioned a full-body makeup and nine-part facial prosthetic makeup to depict a particularly decrepit and battle-scarred orc. Cast in the role was veteran Jackson performer Jed Brophy.



Riding the warg teeter rig, Sharku charges at Aragorn. Viggo Mortensen later performed scenes of his character’s being struck and dragged on a motion control stage, interacting with a bluescreen warg rig, which Weta Digital replaced with warg and orc rider animation.

which Weta Digital enhanced with shards of light, animated to dissipate and reveal the wizard transformed from his previous gray garb into Gandalf the White.

Gandalf reveals that he has been rejuvenated by his conflict with the Balrog, which Aragorn and company believed to have killed him, and recounts his duel with the creature, which continued from the Foundations of Stone, up an unseen 'endless stair' to the top of Mount Zirakzigil. Mary Machlachlan sculpted an 18-inch maquette and a 20-foot-tall, 1/14-scale miniature of the craggy peak, carved from urethane foam with a stone tower emerging at its summit. Peter Jackson's scenic unit photographed a 360-degree view of Dart Valley in New Zealand's Southern Alps, from which Weta Digital's matte painting and digital environment departments created a 3D cyclorama. Alan Lee then produced a Photoshop rendering of the scene using a digital clip of the miniature and background.

The sequence featured an environment of 40 tiles constructed from location photography projected onto 3D valley terrain given a 270-degree rotation, spiraling in to the miniature peak. To accommodate the epic move, miniature department key grip Olly Coleman built a light-mover rig, and motion control camera engineer Moritz Wassmann built a 20-foot-diameter turntable for the set, backed by greenscreen. Alex Funke then photographed the complex camera move by spinning the mountain and lights, while dollying in the camera.

Astride the mountaintop, the 3D-animated Balrog, now wounded and depleted, receives a mortal blow from Gandalf, whose sword attracts a flash of lighting from a nearby storm. Gray Horsfield generated the storm as a 3D volumetric cloud of particle animation extracted from painted elements and practical Balrog smoke. The Balrog then

collapses and plummets to its doom, leaving Gandalf near death, lying frozen in the snow. Jackson's camera closes in on Ian McKellen, tracking in through his eye to glimpse surreal celestial imagery, generated by Wellington digital effects facility Oktobor, and signifying Gandalf's spiritual rebirth.

Gandalf urges Aragorn to take arms against Mordor and leads the way to Edoras, the hilltop refuge of King Théoden, steward of the refugee Gondorians. The camera flies over the countryside, following Gandalf and company, then rises to reveal a tall green hillside capped with a wooden hall and walled village. "We erected the main hall and outlying buildings of the Edoras set on Mount Sunday," said Barrie Osborne. "It was a 200-foot precipice near Mount Potts Station, west of Christchurch. Ninety-mile-an-hour winds routinely blew through the valley; so the sets were framed with massive steel I-beams to withstand the wind sheer. We marked acres of land around that so we could enhance the constructed sets digitally." Matt Aitken visited the location and oversaw detailed reference photography of the Edoras set for texture and modeling reference. Weta Digital then added the village to the slopes of the hill.



A warg rears up over a Rohan rider. Weta Digital supplied 40 full-body CG wargs for the battle sequence, modeled from a Weta Workshop maquette that fused anatomical elements of hyenas and Cape hunting dogs. Dynamic fur simulations were based upon leopard, tiger and wolf pelts. Other CG characters included orc riders, Rohan fighters and horses, and digital doubles for the principal live-action performers. Animators staged battle vignettes between individual characters and layered them into the background and foreground of live-action shots throughout the chaotic attack.

3D structures were affixed to the plate using Auto-tracker, developed for the production by Nick McKenzie. “The success of that shot was guaranteed by Nick’s tracking utility,” stated Brian Van’t Hul. “The tool was based on the Kanade-Lucas-Tomasi tracking algorithm as coded by Stan Birchfield at Stanford University. It allowed the camera department to track thousands of points in a plate and resolve their positions in 3D space employing 3D Equalizer as a calculation engine. Rolf Schneider, the author of 3D Equalizer, assisted by making modifications allowing the huge amount of data to be imported and processed. The final result, aided with practical onset survey data, was a correctly-scaled 3D point cloud of the terrain that locked to the background plate. It was a godsend, and in some cases served our purposes better than hiring someone to do an expensive laser radar scan of the location. That was one of the advantages of working on a production over such a long period of time — eventually the tools we needed started coming to the surface.”



Pursuing an alternate route into Mordor, Frodo and Sam enter the glades of Ithilien, where Gollum attempts to capture dinner in a stream. Andy Serkis, in gimp suit, performed the action on location, splashing after an imaginary fish. Weta Digital rotoscoped Serkis and painted him out of the scene, then composited in the animated Gollum and a CG fish, along with splashes from the plate and digital water simulations.

Using Aitken's photographic reference, Cory Bedwell modeled more than 80 percent of Edoras' 3D structures, which Katie Hecker composited into place with drifting smoke from chimneys and motion-captured Gondorian performers reproduced as crowd simulation characters. Jon Allitt supervised crowd simulations for the film in Massive — software previously devised by Stephen Regelous, who continued to support the production while pursuing commercial applications of his artificial intelligence research.

Gaining entry to the main hall, Gandalf finds Théoden (Bernard Hill) in ill health and in the company of a skulking advisor, Gr'ma Wormtongue (Brad Dourif) — both characters products of Weta Workshop makeups. Dourif shaved his eyebrows and sported a silicone nose and prosthetic wart over his left eye, with pallid skin and a tracery of veins airbrushed by Gino Acevedo. Margery Hamlin and Deb Watson applied a latex stipple makeup to Hill with washes of color and airbrushed detail, then added rheumy contact lenses and an age-mottled bald cap beneath a sparse wig.

Gandalf unmasks Wormtongue as an agent of Saruman, then expels the wretch and cures Théoden's illness, visibly restoring the king before the eyes of his niece '83owyn (Miranda Otto) and nephew '83omer (Karl Urban). Hamlin and Watson applied two additional makeups to Hill to effect the transformation. "Bernard performed his old and sickly state seated against greenscreen," said Jim Rygiel. "We then shot him performing a halfway point, looking slightly younger, then repeated that in his normal 50-year-old state. We morphed between the three as Bernard went through his contortions, and composited him into his chair."

Ending their trek across the Dead Marshes, Gollum, Frodo and Sam halt at the top of a shale slope to view an intimidating iron wall sealing off a craggy mountain pass ahead. Seized by terror, Gollum cowers as a gate swings open to admit an army of Easterlings — men under Sauron's influence — marching past below, adding to the ranks of the Mordor army. Jackson filmed the hobbits on a precipice at Red Rocks, south of Wellington. Alan Lee did a pencil sketch of the scene from a digital clip, expanding the slope around the actors to a vertiginous incline. Matte painters then built up the rock pile using painted and photographic textures, in some places magnifying foot-high rocks into 25-foot boulders, and added a 3D trickle of dust as the hobbits ducked from view to avoid the passing army.

Matt Aitken and Jon Allitt modeled and animated the troop of marching Easterlings, seen from the top of the shale slope, from Frodo's point of view. Jackson photographed Wood, Astin and Serkis



Returning from a successful hunting foray, Gollum presents the hobbits with a freshly killed rabbit. Serkis performed the scene clutching a dummy carcass. Compositors tracked the rabbit's fur to the CG Gollum's fingers.

performing closeup action on a partial set backed by bluescreen. The environment before them and desolate expanse behind them were created using miniature and matte-painted elements. Max Dennison and Yanick Dusseault joined forces to generate two entirely painted digital cycloramas — a 4K vista of craggy mountain peaks and a 6K reverse angle of the Dead Marshes, both used for cuts back and forth behind performers.

Weta Workshop crews constructed the Mordor wall and gates as a 1/20-scale miniature. “*The Black Gates* had to appear as if they weighed many hundreds of tons,” said Alex Funke, “so the model crew built them out of lead sheet, aged to look like rusty iron, and Moritz Wassmann built precision motion-control movers to move them very slowly. The joining faces of the gates were dovetailed so they locked together when they closed. This meant they had to open at different speeds, one a little faster than the other, otherwise they’d bind; so we built a very complex mechanism of linear rails and push-rods to move them.”

Propelling the gates are a pair of mountain trolls — larger relatives of the cave troll featured in *Fellowship* — harnessed to a huge wooden lever arm and whipped into service by orcs. “Mountain trolls are one-and-a-half-times bigger than cave trolls,” stated Aitken. “We put our existing troll model through a deformation to make the mountain trolls really top-heavy and give them a slightly smaller head. We wanted to suggest that these guys had been pushing this bar their whole lives. They were pure muscle!” Intimidated by the Easterlings and the trolls, Frodo heeds Gollum’s advice and pursues an alternate route into Mordor.

At Edoras, Gandalf encourages Théoden to prepare for war, then departs mysteriously on unfinished business. Aragorn, \’83omer and \’83owyn lead the Rohirrim out of Edoras — a combination of live closeups and a Massive crowd simulation tracked into aerial plates — and head for the fortified ravine, Helm’s Deep. At the same time, Wormtongue arrives in Isengard, where Saruman has been busy.

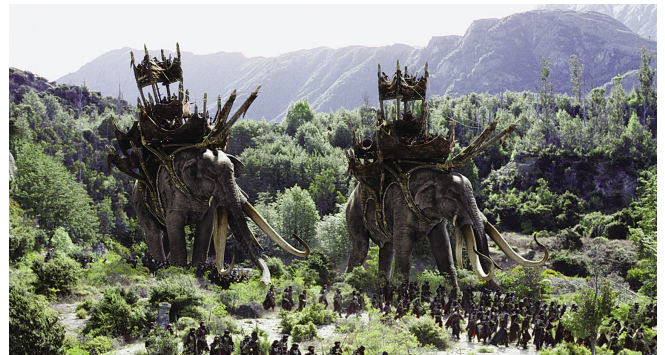
In a Steadicam shot, the camera follows Saruman and Wormtongue through the wizard’s Orthanc tower chamber and steps out with them onto a balcony, revealing Isengard below, filled with a Nuremberg-rally-sized congregation of Uruk-hai. Jackson photographed Christopher Lee and Brad Dourif crossing the interior set to face a greenscreen backing. The shot required extensive hand-tracking in 3D Equalizer and Maya to stabilize a jitter in the camera move. Stephan Remstedt smoothed the lateral motion and blended it with the natural motion in the latter part of the plate. Imery Watson then matched the camera’s forward motion to incorporate the handheld camera operator’s sway as Saruman and Wormtongue take in the Isengard terrain. Laurant Ben-Mimoun created moody matte-painted elements of Isengard, sampling photographic reference of sky, mountain and forest backgrounds and a 1/35-scale miniature featured in *Fellowship*. Geoff Tobin filled Isengard with 9,500 Massive agents representing Uruk-hai, animated to shift on their feet. Patrick Bergeron then composited elements, overseen by sequence lead Seth Lippman.

Saruman addresses his army, inciting them to war. In a trademark Peter Jackson shot, the camera cuts to a reverse angle of the balcony and swoops back at high speed to take in the Orthanc tower with the Uruk warriors in the foreground, raising their weapons and roaring their approval. The track-away from Orthanc was shot as a motion control take on the 1/35-scale miniature, with a separate take of Lee and Dourif shot on the full-scale balcony set. The extreme camera move and

lens distortions, however, presented the environments department with a challenge in aligning the miniature with the full-scale. “The tower underwent so much parallax distortion,” recalled Imery Watson, “it was easier to select frames from the miniature plate, paint those to the plate, then project the textures back onto geometry that matched the features of the tower, the balcony and windows.”

Ben-Mimoun produced three matte paintings of the balcony and tower for the camera move, projecting and re-projecting miniature and live-action textures into the plate. Tobin and Jon Allitt also generated Uruks in the shot at three levels of detail. “We always knew we might need more detail in our Massive agents,” said Allitt. “Our C-level guys had the lowest detail. We only used them in the shots where we had 10,000 or more guys in frame. B-level guys, which had secondary dynamics so their hair and clothing could flap around, held up reasonably close to camera. We held off on building our A-level guys until we were sure we needed them.”

The Isengard pullback featured C- and B-level agents that were blended through layers of 2D smoke and haze, their behaviors created by sampling 55 hours of Massive motion capture recorded for *The Two Towers*. For a final touch of realism, Peter Jackson and a team of sound-recordists paid a surprise visit to a New Zealand-versus-England cricket match at half-time and, with the cooperation of 25,000 spectators, captured the sound effects of jeering and cheering orcs. “We projected the orcs’ Black Speech chant up on the giant video screens above the stadium,” related Jackson. “I had the crowd match the rhythm that we wanted and had all the girls use deep voices, because they all had to be angry orcs. New Zealand won, by the way...”



Frodo, Sam and Gollum witness rangers attacking a battalion of Haradrim accompanied by a pair of dinosaur-sized Mûmakil. Weta Workshop outfitted 60 Harad warriors in exotic red and gold liveries with animal motifs, and sculpted a five-foot-tall maquette of the multi-tusked Mûmak. Weta Digital multiplied the ground-level troops by using repeated takes of Haradrim performers repositioned in frame, and digitally animated two Mûmakil to lumber through the setting with elephantine skin jiggle and muscle dynamics.



Composited into a tiled location background, a Mûmak looms over the hobbits. Key-frame Mûmak animation provided the basis for a motion control shoot that had stunt performers riding a teeter rig representing the mobile battle platform atop the giant Mûmakil. Stagehands rocked the rig in time with Mûmak footfalls.

Using that motion data, Weta Digital created two tiers of digital Mûmak riders that swayed, dangled and even tumbled from the great beasts as they repelled attackers.

Part of Saruman's battle plan is revealed in an excavated pit below Isengard as the wizard visits orc captain Sharku and orders him to circumvent Théoden's escape to Helm's Deep by attacking the refugees with a special orc cavalry division. The miniature unit created a 1/4-scale cavern for the scene, built in three days from Weta Workshop's existing rock castings, fitted with rickety wooden scaffolding, filled with smoke and backlit with straw-colored light.

Later, as Aragorn leads the Rohan refugees cross-country to Helm's Deep, Legolas spies the approaching enemy — orcs riding atop ferocious creatures called 'wargs.' "The wargs were mentioned in *The Hobbit*," noted Workshop designer Warren Mahy. "We modeled them primarily on hyenas and Cape hunting dogs — but ten times their size." Mahy sculpted the warg design maquette at 1/6-scale, then followed it with a 1/3-scale scannable version and a full-scale head for closeup detail. Continuing a Weta Workshop design aesthetic established with the cave troll, Mahy located warg eyes on the outer edges of the skull, avoiding the cliché of deep-set 'monster' eyes.

Weta Workshop also designed the look for Sharku, captain of the warg platoon. "Sharku probably once ruled with some level of control," noted Richard Taylor, "but he has been trying to control these maniacal beasts and has received so many horrific scars, his mind has begun to rot. We imagined him as resembling a freakish jockey. He's stripped down to the least amount of clothing and hasn't attempted to armor himself because he's become so crazed. Instead, he wears a huge warg pelt; so when he's lying flat on the back of his animal, like a jockey, the mane of the warg just literally flows over him and they become a single unit." Dominie Till supervised the application of a full-body makeup to actor Jed Brophy — a Jackson veteran since *Dead Alive* — using scar prosthetics, paint work, contact lenses and a nine-part facial appliance, with teeth and jaw revealed beneath a rent in one side of the character's face. "The lacerations healed about twenty years ago; but as they healed, they pulled out a chunk of his skull. So Sharku has had to fabricate steel bands to hold his skull together. He survived, but he's mentally unstable, almost like a pitbull in Saruman's control."



*Responding to news of the impending war, elves evacuate Rivendell, a setting established in *The Fellowship of the Ring*, now seen in a more autumnal state. Weta Digital retooled its expansive 360-degree digital representation of the Rivendell valley to create a more subdued color palette. Sony Imageworks combined that environment with elements of Weta Workshop's existing Rivendell miniature and greenscreen shots of departing elven citizens.*

On location, Brophy rode a practical warg teeter rig — a ribcage, pelt and saddle, seen in orc rider closeups. For full-screen shots, Weta animated wargs and warg riders digitally, with close attention to muscle and fur dynamics. “Jeff Hameluck wrote a suite of RenderMan tools and Maya plug-ins that comprised our fur system,” said sequence lead Dan Lemmon. “We used that for the ents, creating all the moss and lichen, and in the beards and hair on all our digital doubles and creatures. We handled the wargs a little differently, using shaders that my brother Mark Lemmon and Mark Tait wrote to control the way the fur displaces; but all the fur and hair at Weta stemmed from Jeff’s software.” Rather than have them attempt to match the practical warg pelt, Peter Jackson referred Lemmon’s team to sketches by Christian Rivers and to sabertooth cat animation seen in the BBC television series *Walking With Beasts*. “Christian’s drawings were dog-like, but Peter also wanted the shoulder movement of giant cats. We made the mane long and bristly, swept up and pushed together on top, with finer hairs around the mouth and head, because we were seeing those up close.”

Lemmon’s team generated three main warg color designs — patterned after a leopard, a tiger and a wolf — then created variations among the pack of 40 seen thundering across the Rohan plains. Muscle simulation underneath the skin drove the fur direction. To ease the rendering burden for scenes depicting the entire herd, modelers placed as few hairs as possible on each warg, reducing geometry in the scene, and kept fur translucency minimal.

For a shot of rangers clashing with the wargs, the camera first swung left to right with the Rohirrim charging down a hill, continued up a facing slope encompassing the wargs, then swung back to capture the impact. Weta artists tiled background plates with a pendulum camera move from one plate to another, then tracked in 30 wargs and riders and digital doubles of rangers and horses receiving the brunt of the attack — animation overseen by Carlos Rosas. Digital doubles from both camps were featured prominently in the scene. “There were a couple of bluescreen warg riders in the shots,” stated Matt Aitken, “but most of the time, when you saw riders on the backs of wargs, they were hand-modeled digital doubles, with a lot of work put into their facial animation and the dynamics of their clothing.” Based on Weta Workshop designs, but generated without laser scanning or texture extractions, the warg riders fell somewhere between Massive and hero characters in terms of technology. “We modeled seven warg riders and spent several weeks on each one. The rider designs were very complex, with ears missing, huge chunks of pelt and leather in their costumes. One guy had a warg jawbone built into his armor. We tried to show that the warg riders had a weird symbiotic relationship with their beasts.”



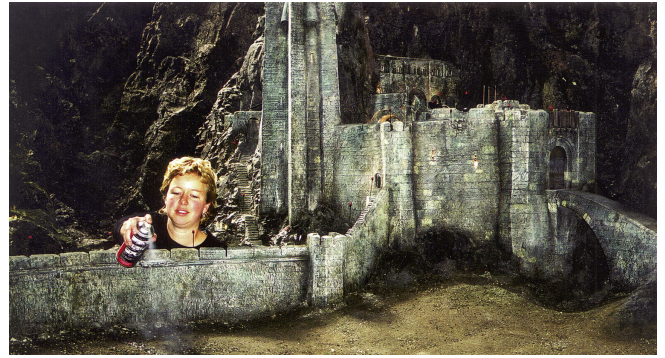
Aragorn and Théoden dig in at Helm's Deep, readying for a grand-scale conflict between the humans and the dark forces of Middle-earth. Based on concept art by Alan Lee, Helm's Deep structures included a giant stonewall, a castle on a cliff and a curving causeway entry ramp. Weta Workshop constructed a 40-foot-square miniature of the setting early in production. Peter Jackson blocked out the action on that miniature, which fed into digital previsualization and art department plans for a larger-scale miniature constructed for establishing shots, and five full-scale set sections.

“The amount of complex animation in this sequence was staggering,” asserted Randy Cook. “Several dozen animated wargs and their riders had to clash with an equal number of horses and humans in shots that were naturalistic, yet dynamic and very ‘in-your-face.’ Each shot tended to feature complicated live-action/animation synchronization in the foreground, as well as numerous background actions of similar complexity. There were a series of ‘battle vignettes’ that focused on individual tussles. Peter Jackson, Christian Rivers and I blocked out each encounter, then layered them into the background — and sometimes, God help us, the foreground — of any given shot, allowing us to depict a ferocious clash of beasts with relative efficiency. The animation team did exemplary work in realistically conveying gruesome carnage. I’ve always respected my team; but now, seeing how bloodthirsty they can be, I fear them.”

Digital and practical effects commingled in a series of shots in which Aragorn, unseated from his horse, stands his ground to face Sharku, then becomes entangled as warg and rider charge by. Viggo Mortensen performed the impact and dragging scenes on a motion control stage, interacting with a bluescreen rig. The sequence concludes with Aragorn and Sharku disappearing over a ridge.

Surviving their conflict with the wargs, Rohan refugees continue to Helm’s Deep. The location is later seen in a helicopter shot circling Aragorn — recovered from his encounter with Sharku — revealing the distant fortress as a miniature and matte-painted element tucked into a ravine. Aragorn meets Théoden, and they walk the parapets of the fortress.

Tolkien named Helm’s Deep after Helm Hammerhand, ancient king of a seafaring race of Nömen—rians, enemies of Sauron, who constructed a giant stone wall across the Deeping-stream, sealing off the entrance to a castle in the southern cliff — the Hornburg — and a labyrinth of caves. Working from conceptual art by Alan Lee, designers first laid out Helm’s Deep in a blueprint illustrating the orientation of the Deeping Wall, Hornburg, a curving causeway that fed from the castle to the valley floor, and a shale slope further down the valley. After Weta Digital artists generated a rough 3D previsualization of the sequence, Weta Workshop re-created Helm’s Deep at 1/35-scale — 23 feet high and about 40 feet square. “That was the first miniature we built, back in 1997, when we were a Miramax production,” recalled Peter Jackson. “We wanted to build something quickly that we could impress the studio with, so we chose that; and we chose 1/35-scale because that was the scale of toy soldiers we could buy. I’ve been a bit of a toy soldier fan ever since I was a kid, so I was in absolute heaven playing with thousands of medieval knights with pikes and bows and swords. I spent quite a few weeks with a lipstick video camera, just figuring out the strategy of the battle based on descriptions in the book.”



Modelmaker Verena Jonker sprays lubricating oil to refresh the wet look of a resin stream running through the miniature Helm’s Deep set. Weta Workshop constructed the miniature using block and sheet urethane for stone structures and sculpted blocks for mountain backgrounds. Weta Digital surveyed all three scales of set and constructed a digital version to help integrate myriad digital enhancements. In addition to torrential rain, flashes of lightning, and matte-painted sky and landscape extensions, Weta Digital layered in flames, hordes of Uruk-hai, war machines and streaming arrows.

John Baster and Mary Machlachlan oversaw construction of the miniature, modifying structures, as needed, to better serve Jackson's lipstick-camera choreography. "As Pete blocked out camera moves, we modified the architecture to help move the story along," recalled Brian Van't Hul. "We added little doorways and passages to help the characters move about." Once the sequence had been firmly nailed down with a revised previzualization, the art department surveyed the 1/35-scale miniature and used the data to build five full-size sections of Helm's Deep in a quarry at Upper Hutt, near Wellington. The art department also built a complete 1/4-scale miniature, approximately the size of a two-story house, carved from foam blocks. Jackson staged all live-actor interactions on the full-scale sections, used the 1/4-scale miniature for establishing shots, and returned to 1/35-scale for wider panoramic views.

Alex Kramer and Nick McKenzie performed theodolite surveys of all the sets to provide the technical foundation on which the enormous Helm's Deep sequence would stand. "All the partial sets and different versions of the miniature needed to be resolved into one digital Helm's Deep," asserted Van't Hul, "so everything would line up as if this location really existed in Middle-earth. We had all been building from the same blueprints; but when we surveyed the structures in different scales, in different locations, none of them matched."

Misalignments stemmed from the vagaries of each location and each methodology. The 1/35-scale miniature, for example, had been designed to include organic detail and irregularities; but, when it was re-created full-size, construction crews had to straighten walls for the sake of safety and structural integrity. The 1/35-scale set was also built on an undulating surface that sloped downhill, and had to be completely disassembled and rebuilt when the miniatures department transferred to a new building. "There were a lot of physical constraints," noted Van't Hul, "such as lights heating miniatures and making them expand, then contract when they cooled, multiple versions of sets built by different teams with different ways of solving problems — but we approached every plate as if it were a fresh effect. Any resources we had were only starting points; and if we had to solve a problem by smushing shots around to make them look fine to camera, that was all that mattered."

To establish the layout of the ravine, Deeping Wall and Hornburg, Jackson staged a shot at Upper Hutt craning up from a view of the crew parking lot, panning over the parapet set and closing in on Viggo Mortensen and Bernard Hill. "The shot used a very wide-angle lens with lots of lens distortion, so we had to deal with de-warping issues," stated Van't Hul. "It was a bit of a wiggly crane move, so we had to carefully track that to lock in other elements and extend the castle walls, making the two-story set appear a lot higher. We aligned the set with the scan of our digital Helm's Deep, and in some cases we used Auto-tracker to figure out where those walls were, adjusting it to



Uruk-hai shatter the Deeping Wall using Saruman's new secret weapon – gunpowder. Physical effects supervisor Stephen Ingram and his NZFX team staged the blast on the large-scale miniature set, later augmented with variously-scaled stones catapulting through the air, shot by Alex Funke's crew. Stuntmen performed wire-pull tumbling gags for motion capture sessions, giving Weta Digital a rich resource of live effects to enhance the scene. The 3D team filled the miniature set with layer upon layer of animated Uruk-hai, siege ladders and pikemen.

fit all the architectural edges. We passed that data to the CG model department and they checked it, blessed it and published it for everyone else to use.” Alex Funke repeated the move on the 1/35-scale miniature, taking in the views of the terrain beyond the wall. Laurant Ben-Mimoun painted rock walls into the foothills of the ravine and behind the Hornburg, animating the towers of Deeping Wall to shift in perspective as the camera closed in on the fortress. Mark Lewis composited elements, adding Massive agents to augment the 100 extras on the set.

Rohan refugees are also seen filing into caves adjoining the back of the Hornburg. Shot in a minimal bluescreen set, with two groups of extras vignettted by rocks crossing left to right through frame, the entire environment — including underground stream and crystalline rock formations — was realized with painted textures projected onto 3D geometry, with a deeper background layer projected onto a curving digital cyclorama. “It was quite difficult to re-create natural light effects,” noted Yanick Dusseault. “Most cave pictures are taken with flash photography, or artificial lights. This cave had to be humongous, with large pools of sunlight reflecting in the water and bouncing off the organic shapes of the smooth wet rocks.” Dusseault added caustic lighting effects, a rippling background stream, and animated thousands of tiny shimmering points of light.

Elsewhere, in the foothills of the Mordor Mountains, Frodo, Sam and Gollum come upon the deceptively peaceful glades of Ithilien. The hobbits stop to eat from their dwindling rations, Gollum vanishing then reappearing with a dead rabbit he has caught for dinner. The scene — the first to test the Gollum pipeline — was one of the most challenging due to its sunlit interaction between the creature and the hobbits. “Bright outdoor settings are one of the most difficult environments to create a CG creature in,” observed Greg

Butler, “so that scene brought up a lot of early Gollum issues. He was on his knees and in extreme positions that pushed the tolerances of our skin and muscle systems. Every time his knees bent, we found his calf muscles went up into his thighs. It also tested how we used Andy as the basis for Gollum.”

Serkis performed the rabbit scene on location in his gimp suit, brandishing a dummy rabbit and biting into it. He later reenacted it during a motion capture session. “We ended up using motion capture for only a couple of those fifteen shots,” said Butler, “but it was through that process that we found what actions were best served by motion capture or by key-frame animation.” Butler’s team used rotomation of Serkis in the Ithilien plate for closeups with the rabbit. “The fact that Andy’s hands were on the rabbit enabled us to track precisely where each finger was, and we ended up using the rabbit from the original plate. We cloned and painted rabbit textures to match fur to Gollum’s fingers. Gollum had longer, skinnier fingers than Andy, so there were issues with every one of those contact points; but having Andy there, creating a performance Peter was happy with, meant that our approvals went much smoother.”

Voices interrupt the hobbits’ dinner, and Gollum joins Sam and Frodo to peer over a grassy rise where they spy a skirmish underway between a troop of rangers and a group of warriors, the Haradrim — another race of people designed and outfitted by the Weta Workshop team. “We wanted to invent a culture that was not easily identifiable as a racial stereotype,” commented John Harding, “so we went to dead races, like the Aztecs and Micronesian cultures, and borrowed from a small island called Kirabati, in the Pacific, where the natives wove elaborate wicker suits of armor.

To show their hierarchy, we had high priests wearing outlandish fans of cane and glass beads across their backs, and we used animal motifs with wolves and leopards. A captain wore a grass and bamboo eagle's head with a big ornate brass beak, and decorated himself with bamboo, precious stones, gold and ivory."

Weta Digital multiplied 60 live Haradrim to 150 by combining repeated takes of actors photographed in different positions, and composited the warriors around and riding atop the source of their ivory supply — two giant, armored, six-tusked, elephantine Mûmakil. "Daniel Falconer drew the Mûmak design," Richard Taylor commented, "and Shaun Bolton and Jamie Beswarick sculpted a large scannable maquette that stood over five feet tall. It was essentially a fortress on legs. It had overtones of a brachiosaur with an extremely small eye socket, a bizarre shovel mouth and 40-foot tusks protruding from its skull, which in battle became perfect scythes." Matt Aitken and his team modeled two Mûmakil from the Workshop maquette. Paul Campion applied textures, and Dana Peters set up animation controls to include skin jiggle and muscle dynamics that resonated with appropriate scale each time the four-story animals took a step.



After capturing Frodo and Sam, a band of rangers spies Gollum lurking by a pool near their cliff-top hideaway. In an attempt to save Gollum's life, Frodo agrees to distract the creature so that the rangers may seize him. Andy Serkis performed the pool scene opposite Elijah Wood during the main-unit shoot, then returned in post production for the filming of Gollum motion capture elements.

Each Mûmak supported a multi-tiered platform in the shape of an inverted teepee, made out of bamboo, wicker and Mûmak hide. Navigators rode the top level and pulled ropes to direct drivers, who sat behind the Mûmakil's ears, with two tiers of warriors behind them. For the filming of Harad warrior closeups against greenscreen, the art department built a full-scale Mûmak platform. Wide shots featured 40 motion-captured Harad Massive agents integrated with Mûmak key-frame animation. To shoot the Harad motion capture, Frank Cowlrick built a roped-off wooden platform resembling a small boxing ring, which rode eight steel springs and a universal joint from a Ford Cortina. "It was human motion control," said Remington Scott. "We rocked our teeter rig with levers extending from the corners, with markers on the rig and on our stunt performers, then played back the approved Mûmak animation, key-framed by Matt Logue and Heather Knight, and timed the motion of our rig with the swing of the Mûmak body. We did that four times for each side, throwing the stuntmen against the ropes and having them hang off; then Jon Allitt's team fed that motion through Massive agents positioned around the Mûmak tower."

Julian Bryant composited Mûmakil scenes using 2D tiled backgrounds, and animated camera moves with shadow passes, stock dust effects and bluescreen elements of bushes simulating footfall interaction. Bryant also performed a 2D camera move in a dramatic shot of a young Harad boy falling into frame almost on top of Frodo and Sam, who look up, startled, to see a Mûmak rearing overhead. Jackson photographed the stunt performer landing in the foreground; Bryant blended a tilt-up to a tiled plate of the rearing CG Mûmak.

Gollum flees the scene in terror, leaving the hobbits to fall into the hands of Faramir (David Wenham), leader of the rangers patrolling Ithilien, charged with preventing Sauron acolytes from passing through to Mordor. Weta Digital placed the hobbits in among the men using composite scale gags — Elijah Wood and Sean Astin photographed greenscreen and layered into plates — as Faramir questions Frodo about his journey.



Motion capture allowed Weta Digital animators to sample high-frequency details of Serkis' live performance, down to trembling fingers and breathing. Subtle key-frame animation then conveyed the shifting spectrum of emotions behind the creature's eyes.

News of the impending war spreads to the city of Rivendell, where the elf-princess Arwen Undomiel (Liv Tyler), betrothed to Aragorn, dreams of two alternative futures for herself and Middle-earth. The scene featured a series of miniature composites and matte paintings retooled from Fellowship. “Rivendell has a time-scale through the trilogy,” related Max Dennison. “In Fellowship, it was at the end of summer. In Two Towers, we were in the autumn; so we changed the colors to reflect the passage of time. It was also symbolic for the elves, as they were preparing to leave their home. We had already spent a lot of time building a full 360-degree environment for Rivendell, so we took that ‘off the shelf’ and created much more subdued color palettes with golden hues.”

Imageworks executed 20 Rivendell composites, including shots of Arwen and Aragorn sharing a romantic moment, using a tiled cyclorama of Weta’s environment beyond the windows, matchmoved to the scene and combined with waterfalls and mist. Imageworks also tracked greenscreen elf performers into wider shots of Rivendell citizens leaving Weta’s miniature city. For Arwen’s alternate vision, foretelling Aragorn’s death, Weta assembled bluescreen elements of Arwen and her father Elrond (Hugo Weaving) with the Gondorian city of Minas Tirith behind them — a multi-scale miniature environment featured briefly in Fellowship. The scene concludes by slowly pulling back from Arwen, shot bluescreen, revealing the princess standing over Aragorn’s body, matted into 1/4-scale and 1/72-scale set pieces. The body then match-dissolves to a marble effigy on Aragorn’s tomb. “It was an extremely long shot,” Alex Funke noted, “more than 1,200 frames, and it showed Peter’s confidence in the effects work that he let it run that long.”

Back at Helm’s Deep, darkness sets in, bringing with it rain and the Uruk-hai army that groups before the Deeping Wall. The scene initiates a battle lasting 25 minutes of screen time, which took three and a



Merry and Pippin accompany Treebeard and the ent army as they invade Saruman’s stronghold at Isengard, wreaking revenge on the wizard for his devastation of their land. The march on Isengard featured a new digital environment culled from an earlier scenic shoot of the Isengard location, while the attack used existing backgrounds modified to suggest moodier skies.



Weta Digital created additional ent characters, reconfiguring their foliage and multiplying them to build an army of 600 arboreal marauders. Compositors combined the CG characters with miniature elements of the destruction of Isengard’s perimeter walls.

half months of night shoots to film. The sequence took full advantage of John Howe's considerable knowledge of medieval warfare, and showcased the full force of Uruk-hai weaponry.

The basic Uruk-hai costume began with a lycra body suit, foam latex limbs, upper body torso, arms, head cowl, then facial mask with teeth and contact lenses. Ten lead actors wore facial prosthetics. Background performers wore masks glued around the eyes. Each suit lasted six days, requiring Workshop supervisor Jason Docherty's team to run foam ovens around the clock for three and a half years, baking thousands of gallons of foam latex to supply the 2,000 suits needed for the Helm's Deep battle. The sequence also required the production of 110 suits of Uruk-hai armor, the originals of which were forged in steel, then molded in silicone and mass-produced in hardcoat.

Finding suitable performers to portray the Uruk-hai was a challenge in itself. "The entire population of New Zealand is only three and a half million people," noted Richard Taylor, "and there are only 250,000 in Wellington. Trying to find 100 guys that were exactly the physique we wanted and were willing, night after night, in the pouring rain, in the middle of winter, to dress in prosthetics and stand for hours waiting to be shot was impossible." Most of the Uruk-hai were cast from the pool of local Pacific Islanders, who were generally shorter than the filmmakers had envisioned for the orc warriors. "We wanted Uruk-hai and we ended up with Uruk-lows. But they were very well-built, wonderful characters, and they were great guys to work with."

Weta Workshop created armor, chain mail and livery for five divisions of Uruk-hai — swordsmen, pikemen, crossbowmen, sappers and berzerkers.

Artists fabricated hundreds of chain mail suits, cutting almost nine miles of chain mail, slicing lengths of plastic pipe into 12.5 million links, zinc-coated and hand-assembled into apparel five times lighter than the real McCoy. Four hundred bows were also featured at Helm's Deep, fabricated from steel rods encased in urethane, sprung with varieties of poundage suitable for background action or closeup practical firing. Five types of arrows depicted insignia of different races. Legolas' arrows and fighting knives were the most ornate, detailed with elven intaglio. His quiver was fabricated from Italian boxwood. The Workshop artists crafted Théoden's armor over a period of four weeks, using bonded, hand-beaten leather, hand-etched and laminated with brass inlays depicting the bursting sun of Edoras and the butting heads of stallions. Such motifs were repeated in the detailing of buckles, pommels of weapons and even the reverse sides of hero costumes to help actors assume the mantle of their characters.

Physical effects also played a large part in the shooting of Helm's Deep. "One of the hardest tasks we had on *The Lord of the Rings* was keeping shots alive," said Stephen Ingram. "We had atmospheric effects like wind and mist in almost every shot." Ingram deferred to three deputies on set, Rich Cordobes running main-unit floor effects, Blair Foord in charge of second unit, and Karl Chisholm



Key-frame-animated ents were pitted against bluescreen and motion-captured orc performers, with crowd simulations filling out the scene. Animators developed battle vignette previsualizations, which were layered behind the animated, bluescreen and motion-captured foreground action. For procedurally generated characters used in deep backgrounds, ent motion capture performers wore prosthetic arm extensions, heavy boots and neck braces to lend them a rigid gait.

handling 'Unit 1B' in between. Mother Nature assisted atmospherics by sprinkling freezing drizzle over the shoot. Ingram's team enhanced the effect with a 50-by-60-foot, crane-held rain bar over the set, pumping water from 10,000-gallon water trucks.

Other practical machinery of war included 40-foot-long ladder rigs, hinged at the base and controlled by decelerator cables, which Uruk-hai stunt performers could climb and ride as they swung toward the wall. Three shorter rigs were used for closeups with a lower rampart set, articulated to make contact with parapets at the correct ramp arc. An Uruk-hai battering ram was also featured at the Hornburg gates — a full-length version suspended by cables from a crane for wide shots, and a pneumatic closeup version used for making contact with the gate. Ingram's team also fired volleys of arrows across the battlefield, using wire-flown effects for closeups and pneumatic arrow-launching rigs for crisscrossing showers of up to 320 arrows per shot. "We made plastic-shafted arrows and put rubber heads on them," explained Ingram, "then slid them over finely-machined brass tubes attached to an air machine. With one burst of air we'd fire all the arrows. They were used against people that were heavily armored; so even if these arrows hit them, they would not be hurt. I caught one in the eye from two paces away and I was okay."

Stunt rigging included an effect on a staircase on the rampart set in which Legolas throws down his shield and rides it down the steps to ground level, firing from his bow. Orlando Bloom performed closeups and a stunt performer enacted wider shots. "We had a 'stuntie' on a harness hooked up on a cable overhead," said Ingram. "We connected his feet to the shield; and by adjusting the tension of the cable, we released him from the top and he surfed down with most of his weight on the cable, using his feet like a skateboard rider. At the bottom of the steps, he kicked off the shield and landed on a crash mat. We hardly controlled his descent at all, so he was almost at full speed going down."

The extent of the Rohirrim's plight is revealed when lightning illuminates a sea of 10,000 Uruk-hai extending to the horizon, shots first developed for a four-minute preview of *The Two Towers* attached to a theatrical release of *Fellowship*. "The trailer included two shots from Helm's Deep," said Joe Letteri, "a wide establishing shot of the Uruk army advancing, with all 10,000 Uruks, then a shot with Uruks swarming up the ladders, the camera swooping up and revealing the battle in full progress. Those really got us going."

One of the shots featured the 1/35-scale miniature, lit and photographed by Alex Funke to match the location lighting established by Andrew Lesnie and second-unit director of photography John Cavill. Funke's team spent approximately two months shooting the Helm's Deep miniature, utilizing previz, camera data and 3D survey as guides, and often shooting digital animatics before committing to film. "Glenn Anderson and Brian Van't Hul designed a fantastic multiple-speed video assist that ran on a Macintosh G4," Funke commented. "This fed from our video tap to the digital recorder, so we could go directly to Photoshop or After Effects and do split-screen combinations and what we called 'bash comps.' We sent those to Peter; and, by the end of the day, we had his approvals."

Funke photographed the miniature using a Praxis snorkel lens on a 24-foot extending boom arm reaching in across the set with the track positioned off to one side. For angles looking out from the Hornburg, Funke's team mounted cameras on a smaller General Lift GenuFlex rig placed inside the

set. The miniature unit used three Fries Reflex Mitchell cameras and four Arriflex 435 Advanced cameras, the 435s making their debut as a motion control camera on the production.

3D lead Wayne Stables and 2D lead Mark Lewis then oversaw the task of assembling the sequence. “For the teaser, Peter gave us one of the toughest shots in the sequence, with the ladders going up against the wall,” Stables recalled, “and that was actually the best thing we could have done. By starting with that shot, Mark and I nailed about 90 percent of the issues that we came across in the sequence; and, in that one shot, we established the lighting that was used pretty much the entire way through the sequence.” 3D issues included background reconstruction. “Environment reconstruction was a very big thing for us. Nick McKenzie set up a system allowing us to easily assemble tiles into a scene, tiling mountain background plates inside a 3D globe. This allowed us to create new virtual camera moves. We used nine tiles in the trailer shot and up to 30 tiles for some of the wider shots. Mike Perry and Mel James did a lot of shader and texture work to create 3D set extensions to the full-scale set.”

3D artists also integrated 3D ladders, arrows, ropes and ballistas — giant crossbow machines that fired grappling hooks attached by rope to ladders — and populated the environment. “Modeling the CG crowds posed two challenges,” commented Stables. “First, we had to make the CG characters look realistic; and, second, we had to be able to generate the images simply. It was a huge computing task to render thousands of guys in a shot. I wrote all our Uruk shaders, which was an exercise in how to make them render as fast as I possibly could, while featuring as much detail as possible.”

Of all the sequences undertaken by the compositing team for *The Two Towers*, Helm’s Deep was easily the most epic. “It had thousands and thousands of characters,” said John Nugent, “vast landscapes, hundreds of horses, and the fortress itself, which consisted of combinations of the partial full-scale set, the 1/4-scale set and 1/35-scale set. Fortunately, the folks in the camera matchmove department, in conjunction with the folks in miniatures motion control, did a beautiful job of linking up camera moves, so the compositors weren’t saddled with wrestling the movement of those elements together.” Miniature composites included sampling the ground plain of the 1/35-scale miniature — which Weta Workshop had detailed so finely it read better than the 1/4-scale — then plugging texture tiles of tufts of grass into the larger-scale terrain. In one shot swooping by the Deeping Wall, Peter Jackson favored a test shot featuring a grip squatting in frame puppeteering ladders. Compositors were thus tasked with painting out the grip, turning the test into a production plate.

Atmospherics would play a large role in integrating elements. “We had lots of ways of achieving fog, mist or rain,” said Nugent. “We generated 3D rain for specific shots and, for others, we made use of generic elements shot years ago for Fellowship. Atmospherics particularly helped in the integration of the CG Massive armies. The 3D team rendered different depth passes of their CG characters in ‘z’ and ‘y’ planes, which allowed compositors to sink them into the fog, making them more hazy the further they were from camera.” For dimensional smoke and mist effects, Craig Wentworth also generated volumetric clouds of smoke as particle animation.

Stables and Lewis established a lighting pattern to break up the masses of digital characters in the scene, bringing out details using backlight and rimlight and dialing back specularities to prevent

highlights appearing too twinkling and intense. Practical flash effects on set drove flash timings on the miniature, which were replicated in digital animation, unveiling hordes of Uruk-hai under sheets of rain. Physical effects also placed 200 burning torches in Uruk actors' hands and rigged the 1/4-scale Helm's Deep set with practical flaming sconces — burning a mixture of acetylene and propane to create more than 100 practical tiny orange flames. Foreground sconces required digital enhancement. To simulate burning firebrands in the animated characters' hands, compositors cycled a generic torch element, attached to cards and tracked to Massive agents, increasing intensities in closeups and hazing in halo effects as they traveled into the distance.

Aragorn gives the order for archers to fire, the battle begins, and Uruk-hai rush forward, swinging ladders up against the Deeping Wall. A low-angle shot of the ladders rising featured Massive agent archers, charging orcs, orcs on CG ladders and motion-captured agents darting close by camera in head-and-shoulder detail. "Our gray-shaded simulations made the action look a lot busier than it actually was," said Stables. "As soon as we lit the shots, we started to see gaps in between guys, and the action looked a little thin. Peter wanted it to feel as if we were in among the action, almost like we were an Uruk-hai CNN cameraman. So we took some of our motion-captured characters, whom we'd shot as stock elements running by, and layered those in front much closer than we'd thought we 'd ever see our Massive characters."



While the battle rages around Orthanc, a commando squad of ents attacks an orc-built dam across the River Isen in the hills above Saruman's fortress. NZFX and Weta Workshop constructed a 30-foot-tall miniature of the dam and flood plain and dumped 35,000 gallons of water into the set. Weta Digital implemented a fusillade of sprite effects, water simulations and 2D compositing tricks to enhance the illusion of scale and eliminate foreground water splashes. Collapsing orc machine miniatures, shot dry-for-wet, and animated orcs and ents caught in the torrent completed the flooding effect.

Arrows became another important composite detail, tracked to plates of actors miming arrow-firing actions. "Arrows were really, really hard," observed Stables, "particularly in really dark shots where they were traveling straight towards camera. We generated fleets of passes using different motion settings and brightness settings, lighting and rendering the tips, feathers and shafts separately. In the end, we simply generated a bunch of arrow passes and balanced them to the plate in composites shot to shot." Imageworks also provided a scattering of digital arrow effects using Weta's arrow models to create streaking volleys and impalements.

Midway through the sequence, orcs advance with explosives and destroy a section of the Deeping Wall. NZFX staged the blast on the 1/4-scale wall, placing mortars and detonator cord in a breakaway section of the miniature, dressed with hardcoated foam blocks and a flow of water behind it to represent the Deeping-stream. Stephen Ingram's team also shot high-speed elements of debris, with and without smoke and dust. To emphasize the scale, Alex Funke's team later shot various scales of heavy stones tumbling and crashing through the air. Motion capture sessions provided elements of stunt performers tugged on wire-pull rigs and falling in flying harnesses, their natural flailing motions fed into the Massive animation pipeline. Mark Lewis' compositing team, working in Apple's Shake, inserted the tumbling characters into a 50-layer composite with

shattering 3D ladders, fire and shrapnel, 2D water splashes and an expanding shockwave heat distortion effect.

As Uruk-hai rush through the breach in the Deeping Wall, a platoon of Uruk-hai swordsmen advance up the Hornburg causeway with shields above their heads, forming a 'turtle' shield wall. "I was very pleased with the design of the siege shields," stated Richard Taylor. "Each one was about as big as a coffee table. There were two hand grips on the back, so when the Uruk-hai held shields over their heads, they released one handle and grabbed the one next to them, and the shields locked together in a fluid armored skin."

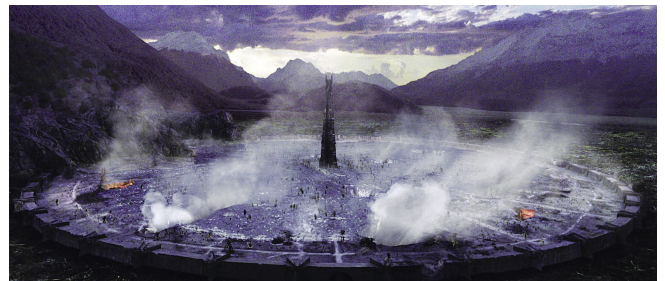
Aragorn and Gimli take a stand on the causeway, beating off wave after wave of Uruk-hai surging at the broken Hornburg gates, seen in a completely animated high-angle view. "We used a hybrid of Massive characters and 20 specific characters interacting with a CG Aragorn and Gimli," said Remington Scott. "We went through a lot of motion editing to coordinate the interactions. Massive provided action of the orcs pushing forward; then, at various points, we isolated one orc, turned off his Massive and gave him motion that would match his Massive move. He'd then run up and strike at Aragorn or Gimli, who we timed to counterstrike. We motion-captured Gimli's stunt double to get the right scale for a dwarf, and we motion-captured stuntmen falling four feet off of a platform into crash mats. Animation extended the falls. Then, in the background, we had Massive orcs climbing ladders and others at ground level swarming through the wall. It was one of the most complex motion capture shots I've seen."

Orcs take the Deeping Wall, but Aragorn maintains a defense as night gives way to day and sunlight begins seeping into the ravine. To achieve the effect of the encroaching dawn, Alex Funke shot the 1/35-scale miniature in shadow, then in sunlight. Compositors then animated the advancing perimeter of light as a soft-edged matte. Sunlight hitting the fallen and animated characters on the battlefield required CG artists to dial back highlight intensity to prevent excessive flaring and pump up resolution of far-distant characters, increasing render times.

Théoden and his remaining men ride out to take their last stand against the orcs, but are surprised to see Gandalf on his white stallion, Shadowfax, atop a shale slope leading into Deeping valley. Gandalf leads a charge into the Uruk-hai — who are dazzled by the sun — with '83omer and a battalion of Rohirrim, returned from exile on the plains of Rohan to reassert their allegiance to Théoden. Jackson filmed the charge into the Uruk-hai army on an



For views of Isengard after the dam burst, Weta flooded its existing 60-foot-diameter model of Saruman's fortress, then shot plates and tiles of the post-diluvial environment. A 'pizza slice' of the Isengard set was filmed dry-for-wet on stage for scenes of digitally animated water rolling in and spreading around Orthanc. Practical flooded plates provided Weta Digital artists with general fluid motion and color textures utilized in computational fluid dynamic simulation.



Giant clouds of steam rise from extinguished furnaces beneath the lake now surrounding Orthanc, destroying orcs and their war machines and trapping Saruman in his

actual shale slope at Upper Hutt, while wide shots of the slope were achieved with miniature and matte-painted elements. Mark Lewis performed a 17-degree rotation on the charge, increasing the dynamic canted angle of the downward gradient.

Rotoscope artists isolated Gandalf, Shadowfax,

\83omer and his men, enabling Lewis to insert

riders between painted foreground and background

rock elements, printing Gandalf and his horse to a dazzling pure white. Painted elements disguised a blend to a second plate of orc pikesmen. Lewis animated a 2D move between the plates, layering Rohirrim and Uruk-hai to create the illusion of horses charging into pikes. John Haley supplied additional horses and Rohan riders as Massive agents to extend the Rohan army. The PostHouse team — under supervisor Peter Doyle — gave the shot a final dramatic grade, lifting highlights and leeching colors to produce gritty detail in the shale to contrast Gandalf's supernatural radiance.

“Helm’s Deep was an immensely difficult, immensely challenging sequence for everybody,” Wayne Stables remarked, “but it was also a labor of love. We got to play with castles and soldiers and cinch ladders — and visual effects don’t get much better than that.”

While events run their course at Helm’s Deep, Faramir stands looking out from an Ithilien cliff-top retreat, Henneth Annûn, backlit by the moon. The scene featured a digitally enhanced practical waterfall, a bluescreen foreground element of Faramir and matte-painted enhancements to scenic plates of Ithilien. “We always used photographic elements in midground and foreground,” noted Yanick Dusseault, “but we got away with more interesting painted effects in night shots. We used a slightly more painterly style in the shapes of the trees to make them a little more romantic than they would be in real life.”

Faramir spies a figure scampering in the rocks below and advises Frodo to lure the creature into a trap. Frodo ventures down to where Gollum is splashing in a pool, merrily beating the life out of a salmon. Peter Jackson shot the high angle with a Gollum double in the gimp suit, then photographed Elijah Wood with Andy Serkis at the pool, Serkis manhandling a weighted rubber fish. He later restaged the Gollum element as motion capture, with Gollum turning to look at Frodo, pausing, barely moving, his chest heaving. “It was always part of our plan to have moments of restraint in Gollum/Sméagol’s performance,” observed Randy Cook. “This is the type of action motion capture does so well: call it ‘stillness capture.’ This is something I have always admired and attempted to achieve. CGI animation often ignores the value of stillness as a vital acting tool. As it happened in our production schedule, the encounter at the pool was the first instance where Gollum was required to behave with this sort of restraint, so it was the first scene we animated that showed the subtleties and shading of Gollum’s performance. I think it demonstrated to many Gollum’s true potential.”

tower. Weta Digital tracked the encroaching lake into 3D geometry of the environment – assembled from Weta Workshop miniatures and a digital cyclorama of scenic imagery – then added 3D models of drifting wreckage, particle animation and water sprites. Splash effects were created through a combination of sprite technology and particle emissions. Steam clouds were derived from Balrog smoke elements.

Another key to Gollum's animation lay in a less tangible realm behind the creature's eyes. "The camera is a lie detector," remarked Cook. "When you're animating, you're lying at 24 times a second. You have to think not in terms of poses or expressions so much as thoughts and feelings. What I asked the animators to do was to write out a dialogue track for Gollum's thoughts and pose them out. We found that certain thoughts would change at certain intervals, and once we had those timings, they took us a long way towards conveying what Gollum was thinking and feeling. We didn't have to know exactly what he was thinking and feeling; but when the animators went through those steps, playing out his thoughts with facial expressions, sans lips, the effect was quite successful."

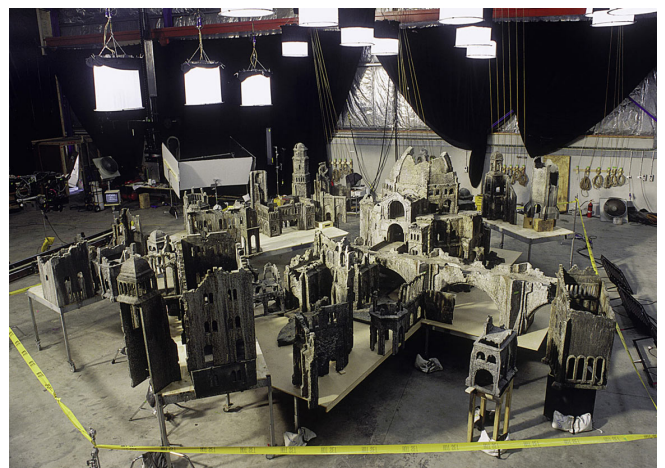
Frodo lures Gollum from the pool, promising the creature his protection, then Faramir's men pounce. Gollum screams in terror and fury until rangers wrestle him down and thrust a bag over his head. Jackson shot the scene with the rangers seizing and bagging Serkis. "We rotoed Gollum to Andy, and then we rotoed the bag as it went over him," explained Jim Rygiel, "using paint effects to make it all fit. As they carried him away in a wider shot, we shot a pass with the rangers miming pulling on Gollum's limbs. We animated Gollum's arms to fit, and used a cloth simulation for the bag." Heartbreakingly for Frodo, Faramir's men subdue Gollum by kicking him into submission — actors booting a bluescreen bag, later replaced by the animated character.

After the battle at Helm's Deep, Treebeard leads his army of ents to the ravaged valley of Isengard. The environment required matte painters to assemble a new 360-degree set of tiles, culled from an earlier scenic shoot of the Isengard location. The ent march also required the CG model department to produce 21 additional ents, created by manipulating Grove parameters to produce new configurations of leaves and branches among the eight existing species.

Although the majority of animation in the ent march was key-framed using Dana Peters' animation controls, deep background ents were reproduced by Jon Allitt's team as Massive agents, tracked to splines on the 3D terrain and programmed with uniquely ent-like motion-captured movement. "We analyzed the physicality of each tree," explained Remington Scott, "then Frank Cowlrick created prosthetics for the motion capture performer to wear, retargeting the actor's movements. If we had a smaller, stumpier tree, the



Still in the company of the rangers that captured them, Frodo, Sam and Gollum arrive at Osgiliath, a city straddling the River Anduin, the original capital of Gondor, now half-ruined, under siege by an orc army on the far bank. Jackson photographed wideviews of the city at a river location outside Queenstown, then shot closer scenes on a soundstage set backed by bluescreen. Weta Workshop built three scales of miniatures to represent crumbling architecture grouped around a shattered central dome. Weta Digital blended the elements and added matte paintings of distant Mordor mountains.



actor wore padding. If it was a thin and wiry tree, the actor walked on weighted boots so when he stepped it made him really plant his foot. The performer also wore a neck brace to keep his back straight, and arm extensions with articulated fingers so he could open and close his elongated digits. Character Mapper translated all this movement to our 3D ent in real-time, which we could see on our monitors or by using virtual reality goggles.”

Disgusting toward Weta Workshop stationery requirements of polished Motu axes from moves descended from a 3D wireframe, and painted the hair with black acrylics. Jeremy Bennett, who utilized digital still frames of miniatures as a basis for Photoshop renderings of skies, environments and characters.

Reaching the once verdant valley, now stripped of trees, Treebeard and his ents march upon Orthanc to exact revenge on the wizard who has been murdering their race. “As Tolkien’s readers will know,” Peter Jackson commented, “in the book we arrive at Isengard after the fact and he describes what happened there in a flashback. The studio was quite keen for us to do it like the book because it would have been cheaper; but I always felt it was something we should see. We set up a very potent visual in Fellowship, showing Saruman ripping down trees and throwing them into furnaces to feed his industrial machines. I felt it was important to see the trees strike back, wreaking their vengeance on Saruman.”

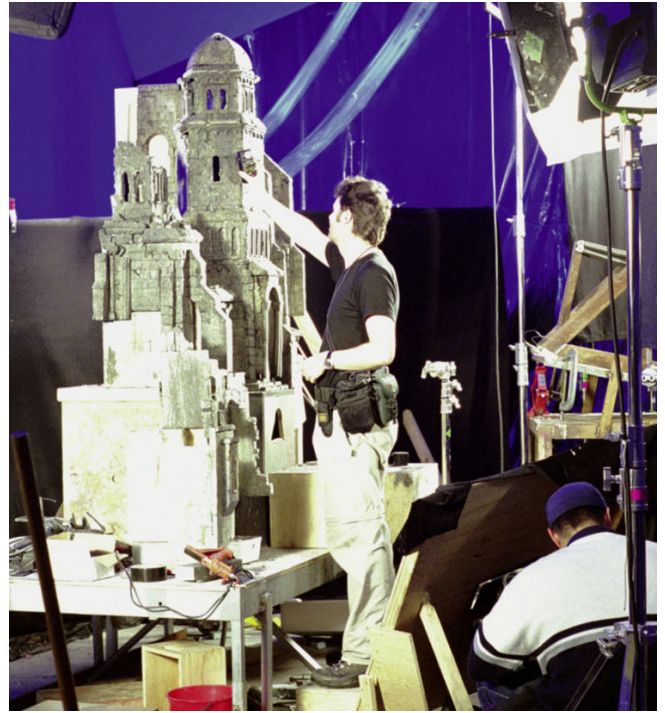
The establishing shot — tracking and panning with the ents as they descend a slope toward Isengard — was based on an existing 360-degree digital environment used in Fellowship, re-tiled with moodier skies and viewed from a reverse angle. Hero-animated ents fill the foreground, passing close by camera from left to right, with a rear guard of 600 Massive agent ents, all engaging in a fearsome pitched battle. “We had ents picking up boulders,” remarked Jim Rygiel, “and throwing them at orcs, orcs firing back, chopping at the ents with swords, firing arrows at them, setting fire to them — all of it completely digital, using motion capture, key-frame and Massive animation.”

Hero beats of battle action were achieved by pitting key-frame-animated ents against bluescreen or motion-captured orcs. Randy Cook and animation supervisor Richard Baneham worked with an ‘ent team’ of fifteen animators to develop battle vignettes. “Christian Rivers and I roughed in camera moves and presented our ideas to Peter as previz,” Cook stated. “After we incorporated the vignettes into shots, we augmented them with foreground key-frame animation and, in the distance, Massive crowd action derived from motion capture.”

Alex Funke's team shot physical elements for the destruction of Isengard's circular perimeter walls by the ents, used by Mark Lewis' compositors in assembling the apocalyptic scene. Christian Rivers, Brian Van't Hul and Funke shot handheld digital video animatics using little stand-in ents and orc puppets to illustrate ideas for specific effects, such as ents breaking the wall or toppling an orc tower. Using the hand-puppeteered bash-comp technique, Funke, Rivers and Van't Hul cut together a Macintosh iMovie depicting the ents' revenge on Isengard, which included destroying an orc-built dam and flooding the fortress. "We built a rough model of the dam," said Van't Hul, "based on Alan Lee's drawings. Then, in the course of about a day, Alex, Christian and I destroyed the model, shooting very quick DV-cam animatics."

With Jackson's approval of the animatics, the art department, NZFX and Weta Workshop crews collaborated on the building of a 1/6-scale dam inside Three Foot Six's 'Studio O' — a Port of Wellington warehouse. Over a period of two weeks, the crews constructed a 30-foot-tall set and a floodable ground plain of Isengard pits and caverns. "We would have preferred 1/4-scale or 1/2-scale," said Funke, "but we went with the biggest that was practical to build, and shot it all indoors to control the lighting." As part of the dam build, NZFX crew members used a crane to insert stone blocks fabricated out of vermiculite, sand, cement and polypropylene, ensuring that the wall would not break apart too easily and stones would be heavy enough not to float downstream. Weta Workshop built and detailed the Isengard miniature for the same sequence.

To produce the flood, NZFX rigged four overhead tanks, capable of dumping 35,000 gallons of water, above the miniature. "We made dump tanks out of shipping containers," recalled Stephen Ingram. "We cross-braced them, strengthened the sides and fitted the doors with rubber seals to make them watertight. We ran chain from the front of the doors to the back of each container, and held them closed with a trip release. We could release them instantaneously and control the head of water



Miniature unit gaffer Rob Kerr and camera operator Matthew Parsons prepare an Osgiliath set piece prior to filming a low-angle view of the tower's destruction. Modelmakers built the tower with a steel internal structure that ensured a repeatable shattering effect when struck by a concrete missile, a practical effect hurled by a catapult from camera right.



Miniature unit grip Peter Smith attends to the motion control system during a flyover of the Osgiliath cityscape. Weta Digital flopped and tiled high angles of the miniature to double the city's apparent size for a descending aerial point of view.

based on how much we tilted them and how much we filled them up.” Ingram’s team added an anti-foaming agent to the water to help break up surface tension and maintain scale.

Brian Van’t Hul supervised photography of the dam, shooting high-speed to enhance the scale. “The classic rule of thumb is to take the square root of the scale and multiply that by 24 to determine camera speed,” Alex Funke observed. “But that only works for objects in free-fall, like miniature trucks falling off cliffs. For elements that have their own internal dynamics, like water or fire, you shoot by gut instinct and then you test. In this case, 72 frames per second was the most convincing.”

The crew spent a week shooting clean and tile plates of the intact dam, then covered the explosion with multiple cameras from a variety of angles, shooting from underwater boxes and craning from the waterline to rise through the shot. The first take of the water hitting the dam revealed a design flaw in the plan. “Everything was ready,” recalled Van’t Hul, “we rolled cameras, triggered the doors and, boom!, water hit the wall and the dam bowed out — but it didn’t fall. Water just came streaming through like a giant sieve.” An hour-and-a-half refill and one repeat take later, the dam still failed to budge, held in place by the tonnage of its bricks. “At that point, we started to appreciate why all those castles are still standing in Europe — medieval architects really knew what they were doing! A few brave art department guys attached a big tow strap around some of the blocks and yanked it with a forklift. The middle came out and we tried again.”

After rebuilding the miniature and carving into the off-camera side, the dam came down in spectacular fashion, taking with it networks of wooden sluices and foreground towers. Van’t Hul’s team continued to shoot for three weeks, capturing random flood effects to help Jackson build his cut and for the compositors to use as elements for sprites. Later in production, sequence supervisor Jamie Price joined the Weta team to oversee integration of effects in the flood sequence, working with Mark Lewis and Gray Horsfield to develop digital water simulations and remove the curse of oversize spray and splatter.

Horsfield shot sprite photography during the final week of the miniature shoot, making use of a physical effects rig. “I asked for something that could launch fifty liters of water into the air instantly,” Horsfield explained. “Stephen Ingram’s guys built a huge drum out of inch-thick steel. Inside it was a big pneumatic piston driven by compressed air, shooting 400 psi through a one-inch nozzle. We filled that with water mixed with a little milk to make it read better against black, then blasted 50 liters of water 60 feet across the warehouse. We shot it from every conceivable angle and put wire meshes and obstacles in front of the barrel to break up the spray. It was a very effective way to avoid having to



The Nazgûl introduced in The Fellowship of the Ring return at the end of The Two Towers as ‘wraiths with wings,’ with the Nazgûl Witch King seated atop a giant bat-winged creature, known as a Fell Beast. Modeled from a John Howe design and a Weta Workshop maquette, the CG FellBeast was animated to resemble a carrion bird with a wingspan approximating that of a jetliner. Weta Digital animated the wings to flex and billow like those of a bat and rendered the fearsome creature with purplish-black, opalescent scales.

create trillions of simulated particles — which, of course, we didn't have time to do." The sprite material " and a few selections of water textures created for the Ford of Brunin sequence in Fellowship " formed a library of water samples that Horsfield and Lewis incorporated into simulations and composites to atomize scale-destroying water drops in the miniature plates.

3D water effects for the flood sequence were achieved through computational fluid dynamic simulations in Maya. "Maya CFD flows are not made up of simple points in space," explained Horsfield. "They're made up of voxels " three-dimensional volume elements " each with different pressures of direction, velocity and force. We took this mesh of pressures, applied it to a particle animation system and fed particles into it so they inherited fluid dynamics." Once Horsfield's team established the flow of volumetric particles through a shot, they affixed water sprite textures to particles and poured them through the terrain. "We developed what we called 'soft sprites,' which were soft-body NURBS surfaces. Each sprite was rigid on the front and flowed through the simulation, bouncing off its neighbors, while particles on the back were soft-body patches, which rippled like flags."

Horsfield's team created Maya dynamic fields to disrupt the flags wherever the simulation broke up in more turbulent areas. On top of this, artists projected texture maps of rolling, tumbling and turning water, fed into the fluid system by the thousands. Artists tracked water shapes using lattice deformers to define the body of the water moving through the dam. Horsfield translated a leading-edge-shaped NURBS patch to the deformer. Simulations then flowed through this surging 3D shape. Emission maps further agitated particle behavior.

Final flooding shots were created with a mix of 2D and 3D water elements. "The biggest task was to break up the appearance of the miniature water to enhance its scale," said Joe Letteri. "We most often used 3D water and spray to break up the leading edge, with 2D river elements adding volume to the body of the water. Occasionally, we reversed that mix." Massive ents and orcs and debris completed the effect. For shots in which Treebeard digs his roots into the ground and braces himself against the impact of the torrent, digital artists utilized a copy of Gollum's wet shader. Alex Funke also provided dry-for-wet destruction elements, using an ingenious model-smasher trick devised by Simon Greenway and Jeremy Barr. By rigging 24 1/10-scale orc machines with weights on wire and pulley mechanisms, then dropping the weights, they yanked miniatures flat or pulled them sideways in precisely choreographed smashes, filmed at 120 frames per second.

Floodwaters roll in, covering the plain of Isengard and gushing into its open pits. Horsfield and Lewis assembled the scene using 1/6-scale miniature shots, 1/32-scale elements of water smashing orc equipment and dry-for-wet plates of the 1/35-scale miniature. "We put together a 'wasted and flooded unit,' which made for quite a good crew shirt," stated Brian Van't Hul. "We flooded our big miniature of Isengard, which was 20 meters in diameter, with the Orthanc tower standing about five meters tall. We shot several plates and tiles, then relocated the walls to another location and fitted them with a pool liner, which allowed us to shoot extensions to live-action plates where characters are seen wading through the water after the flood." The postdiluvian scene featured giant clouds of steam rising from extinguished furnaces " adapted from Balrog smoke elements " and a large fluid dynamic simulation of the lake filling Isengard.

Faramir leads Frodo and Sam, with Gollum on a leash, toward the island city of Osgiliath, the original capital of Gondor, straddling the River Anduin midway between Minas Tirith and Mordor. Faramir now finds the city half-ruined, an army of orcs besieging its far bank. Jackson staged wide shots of the city at a river location outside Queenstown, then shot city scenes on a soundstage set backed by bluescreen, flooded knee-high with water. Long shots and high angles were augmented with matte paintings and miniature effects.

Weta Workshop built Osgiliath's architecture "1/10-scale foreground arches and bridges and 100 1/50-scale structures grouped around a central dome" from carved foam and sprayed urethane. The cityscape and river miniature encompassed an area of 16 by 32 feet, with 1/10-scale structures covering 30 square feet. "Time was of the essence," said Mary Machlachlan, "so we reused some architectural pieces we had made for Minas Tirith. We also very quickly sculpted a few statues, casting arms and accouterments separately so that we could alter positions of different statues. We gave structures a base color using water-based acrylic house paint, then the miniatures unit dressed the buildings to camera."

Motion control operator Hugh Smith designed Osgiliath shots, taking his lead from 3D camera data or shooting elements based purely on conceptual art provided by Alan Lee and Jeremy Bennett. Using digital clips of the Osgiliath miniature, Lee and Bennett sketched Photoshop renderings, painting skies, environments and characters. Alex Funke's team aligned miniatures to the compositions and shot tiled elements using motion control software developed by Chris Davison. "We delineated the four corners of the image," said Funke, "then Chris's program automatically calculated focal length and overlap, and shot tiles in bursts of 24 frames. We handed the environments department our Kuper move files, and they used that data to stitch tiles together."

Hiroaki Muramoto fused miniature elements with location plates and matte paintings by Roger Kupelian. "We created two almost-180-degree digital cycloramas of Osgiliath," said Kupelian. "The first time the rangers come over the ridge and see the city, the city was a miniature; but it lost a lot of detail when shrunk down in frame, so that required a lot of painting. Everything around that and along the river was painted. I used a reference of ruined Arabic cities, and for the mountains sampled everything from Mount Ararat to the Matterhorn. The location had a real Ararat plains feel to it, so I tried to preserve that feeling." Lower angles inside the city required Kupelian to cheat horizon lines higher in the frame to allow glimpses of the distant Mount Doom, complete with animated lightning and volcanic activity.

In a mysterious trance, Frodo wanders from the group and finds himself alone on the battlements. Suddenly a Fell Beast swoops out of the sky. Alex Funke shot high angles descending over the 1/50-scale city to simulate the creature's point of view closing in on Frodo. Weta Digital flopped and tiled the take to double the city's size. Funke then shot 1/10-scale foreground structures layered with 1/72-scale elements as tiled plates for a dramatic low angle of the animated Fell Beast rising up from the bottom of the frame like a Harrier jump jet. Not a moment too soon, Sam and Faramir leap to Frodo's aid. "We adapted that scene from a moment in the novel when Frodo goes into a strange trance and sees the Nazgûl Witch King on his way into Mordor," noted Peter Jackson. "By bringing that into Osgiliath, which is a setting Tolkien refers to obliquely in his novel, we formed a

climax for Frodo with Faramir. So we were mucking around with the book a little there, using Tolkien's material in a slightly different way."

The hobbits leave Osgiliath and emerge into a forest to head for Cirith Ungol, a treacherous and hitherto impassable path into Mordor, which Gollum gleefully promises he can navigate. Jackson and his co-writers wove together two moments from Tolkien's book to create the scene that closes the film. Gollum scampers ahead as Sam and Frodo trudge through the forest. Catching up with Gollum, the camera then lingers and tracks him for one fluid, unbroken shot to reveal the creature as he considers his options. "It was a huge two-and-a-half-minute scene," recalled Jim Rygiel. "Gollum was full-body-animated throughout, talking to himself, saying, 'If I kill him now, I can get the Ring; but maybe I should bring him to her...' — and there's a mystery as to who he's talking about. We held off on animating the scene until late in production because it was so demanding; so early on, our CG Gollum was just a gray-shaded form moving through the plate, but it was still mesmerizing! Andy Serkis' performance was so conflicted and tortured — 'Yes, yes, yes, I'll kill him! No, no, no! I'm not going to go there!' Then, at the end, he says brightly: 'Okay! Come on, let's go, hobbits!' It was a great way to end the film."

Serkis performed the scene wearing his gimp suit in a live forest location, a Steadicam operator tracking with him as he passed between the trees. The 3D camera team created a temporary camera move for the initial motion capture sessions, later reworked by Stephan Remstedt. The terrain and camera data was then passed to the mocap team and reengineered to fit within the volumes of the stage. "We wanted to capture the really fine detail of Andy's performance," stated Brian Van't Hul. "To do that, we had to position our motion capture cameras quite close to Andy, because the larger the volume we were capturing in, the fewer subtleties we picked up. This was a huge path through the forest and we couldn't fit it all in the studio; so we carved it up into three pieces, picking and choosing important moments. The early part of the shot was more about Andy's movement from 'A' to 'B,' so we covered that in a larger volume. As he came up into a closeup, it was more about him quivering and creating subtle movement, so we covered that in a smaller volume."

For the final animation of Gollum's soliloquy, motion editors cut the motion-captured action together, attempting to preserve the subtleties of Serkis' natural movement, then handed that off to motion editors Sandra Warren and Jason Schleiffer, who refined the body moves, and animators Michael Murphy, Adam Valdez and Mike Stevens. All took advantage of Serkis' mastery of the role. "By the end of shooting," said Peter Jackson, "Andy lived and breathed Gollum. He knew Gollum's psychology; he knew Gollum better than anyone. With virtually no exceptions, my direction to the animators was simply: 'Make Gollum move like Andy. Copy every facial twitch and nuance on his face.' The results were remarkable."

"It was sometimes hard to tell where Andy left off and the animators began," added Randy Cook. "We worked on that scene with Peter, Fran and Philippa up until our last months of production, refining ideas, incorporating elements of Andy. It was a great opportunity to show the good side and bad side of Gollum's personality at war with each other. By sublimating themselves to Andy's initial performance, the animators were able to work in concert with Andy — he played the melody, while they did solo riffs off that melody."

As Gollum merrily rejoins Frodo and Sam, the camera rises through a canopy of trees and up a shale slope to a final view of Mordor. Jackson filmed the first part of the scene as a crane shot rising into trees. Brian Van't Hul oversaw photography of a miniature tree wipe element that matched the move and aligned with a live-action helicopter shot — supervised by Jim Rygiel — that rose above a forest. The conclusion of the scene, finalized in the last six days of shooting, incorporated a matte painting by Michael Lloyd and a miniature. “The final shot was a big, scary ride up this jagged rock wall,” explained Alex Funke, “accelerating faster and faster, then easing to a stop overlooking a craggy cliff, with Mount Doom erupting behind Barad’dûr and Nazgûl swirling overhead. We built a 1/100-scale cliff that was 16 feet wide and more than 40 feet long, parallel to the ground so that the camera could run the length of it. We shot the moves, bash-comped them at Weta, then e-mailed them to Peter while he was scoring the film in London.”

With two-thirds of the journey complete, the juggernaut of *The Lord of the Rings* rolls on for Peter Jackson’s fellowship in Wellington. As the trilogy nears completion, Jackson continues to attribute the films’ appeal to the power of the source material. “Making the movie, I’ve certainly developed a deep appreciation for the themes of the story that were important to Tolkien,” Jackson stated. “We tried very hard to interpret what we felt was important to Tolkien — why he wrote the books, what inspired him to spend all that time writing them — without imposing our own agenda. We felt quite strongly about that.

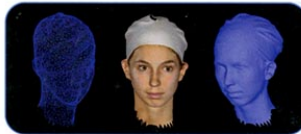
“I also wanted to make a movie that entertained people in a way they haven’t experienced in a fantasy film before. We wanted it to feel quite authentic and real. I’ve always been frustrated with fantasy films for not doing that. The original *King Kong* is my favorite movie. The events and the images in that movie are outrageous, but everybody played it for real. I’ve always thought that was how fantasy should be in movies, so I was very happy to finally have the chance to try something like that myself. I was even happier, of course, when people responded in the way they did. They obviously appreciated that we had made a movie that felt a little fresh and a little different.”

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